BULLETIN of THE LOWELL TECHNOLOGICAL INSTITUTE 1970—1971

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of

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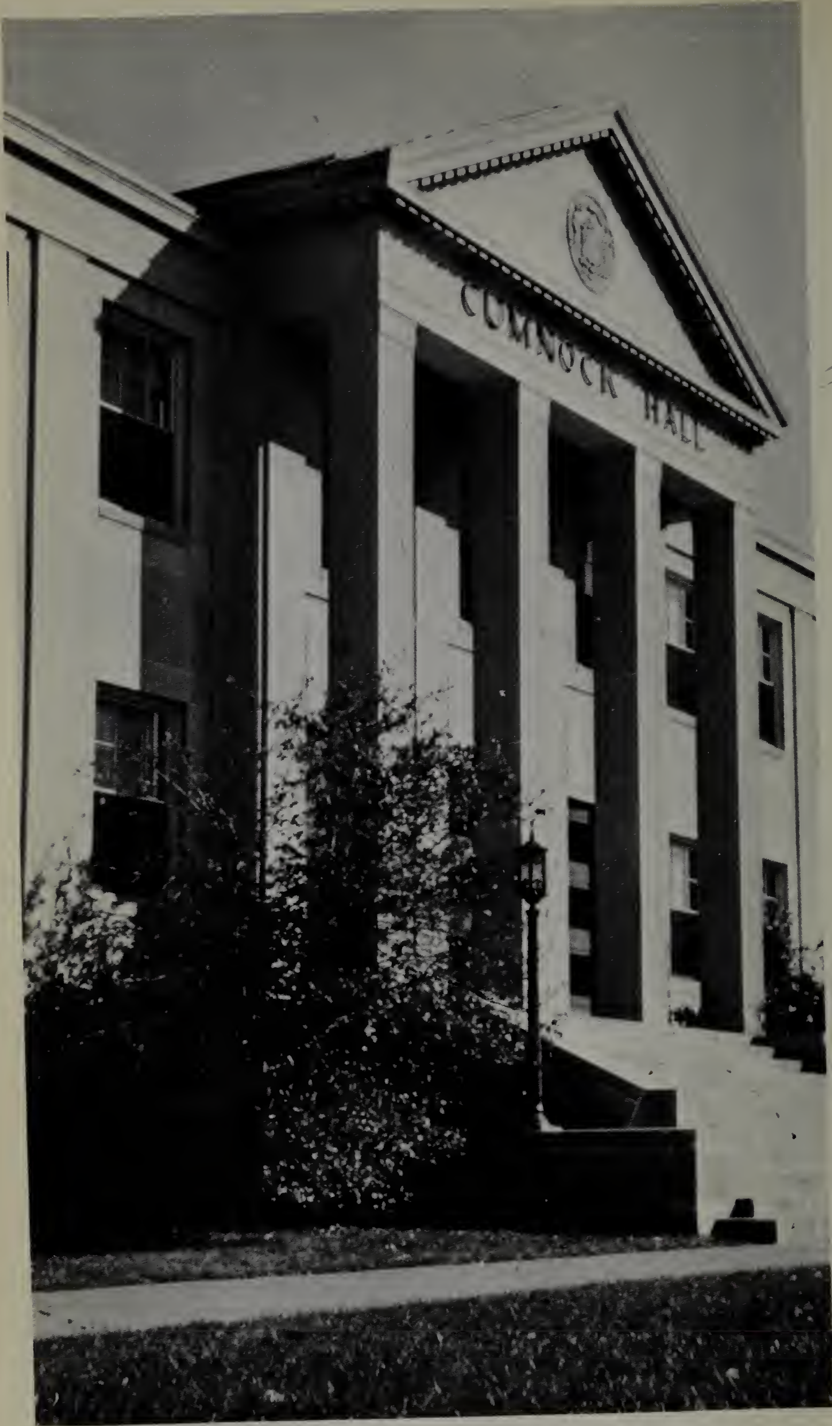
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Lowell, Massachusetts 01854

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ACADEMIC CALENDAR, 1970-71

September 8, Tuesday	Freshman Orientation Week begins.
September 9, Wednesday	Registration of graduate students begins. Registration of seniors.
September 10, Thursday	Registration of juniors.
September 11, Friday	Registration of sophomores.
September 14, Monday	Classes begin.
September 23, Wednesday	Last day to register for new subjects or to drop a subject without approved academic petition.
October 12, Monday	Institute closed. Columbus Day.
November 11, Wednesday	Institute closed. Veterans Day.
November 24, Tuesday, 6 p.m.	Thanksgiving recess begins.
November 30, Monday	Classes resume.
December 18, Friday, 6 p.m.	Christmas recess begins.
January 4, Monday	Classes resume.
January 8, Friday, 6 p.m.	Classes end.
January 11, Monday	Examinations begin.
January 19, Tuesday	Semester ends.
January 26, Tuesday	Registration of graduate students begins.
January 27, Wednesday	Registration of seniors and juniors.
January 28, Thursday	Registration of sophomores.
January 29, Friday	Registration of freshmen.
February 1, Monday	Classes begin.
February 10, Wednesday	Last day to register for new subjects or to drop a subject without approved academic petition.
February 15, Monday	Institute closed. Washington's Birthday Observance.
April 2, Friday, 6 p.m.	Spring recess begins.
April 12, Monday	Classes resume.
April 19, Monday	Institute closed. Patriots Day.
May 21, Friday, 6 p.m.	Classes end.
May 24, Monday	Examinations begin.
May 31, Monday	Institute closed. Memorial Day Observance.
June 3, Thursday	Examinations end.
June 13, Sunday	Commencement.

Normally, classes are held from 8 a.m. to 6 p.m., Monday through Friday. This calendar is subject to change without notice.

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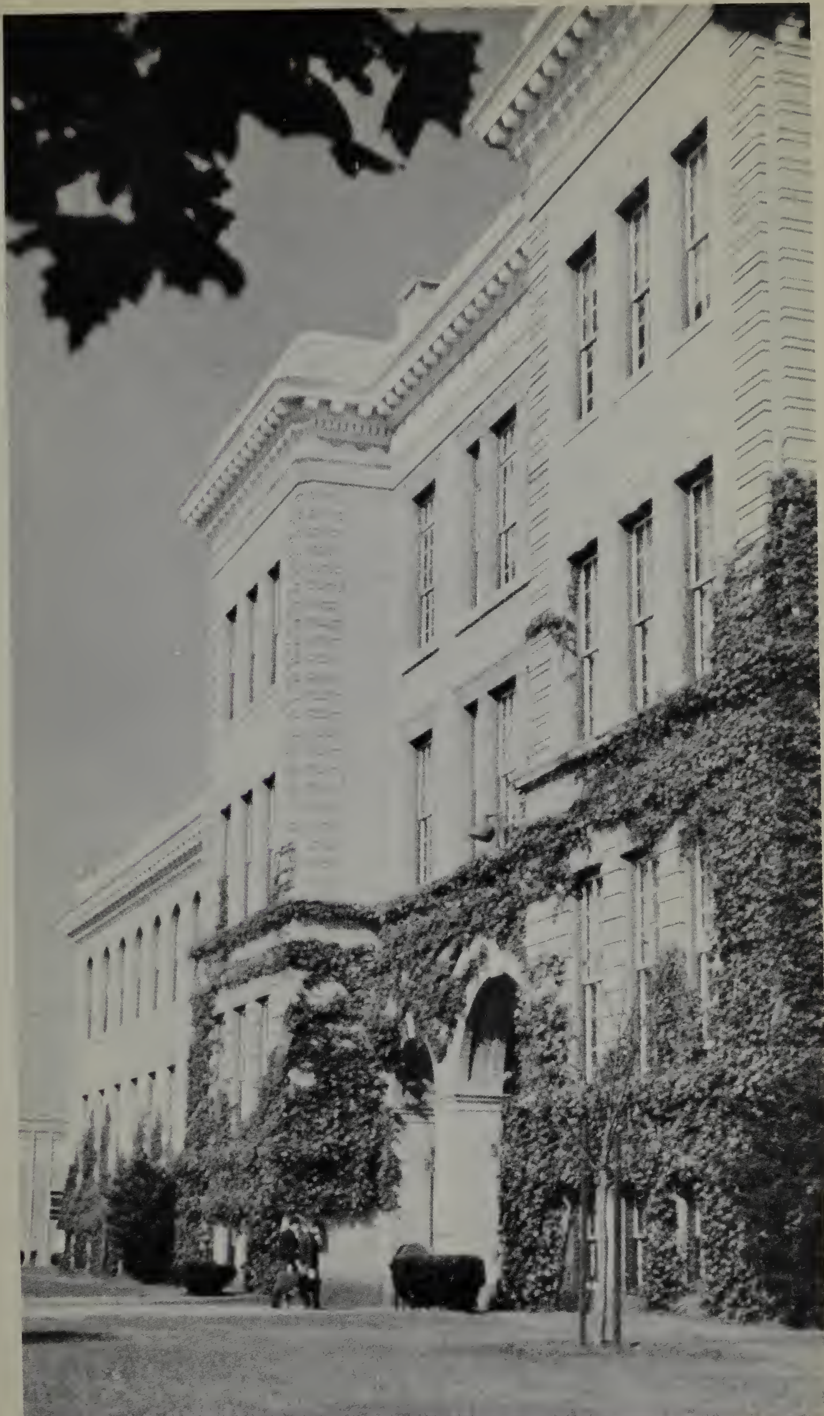

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GENERAL INFORMATION

History and Aims

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School an awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry. In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration, meteorology, and biological sciences. In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to Lowell Technological Institute. The Institute grants Bachelor of Science in Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees. Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

The major aims of Lowell Technological Institute are to furnish sound educational programs in science, engineering, technology, business and management at both the undergraduate and graduate levels to cultivate in its students a professional attitude in their fields of concentration and to develop their ability for creative thinking. All education, and particularly in the fields of study offered at the Institute, must be based on a thorough grounding in the fundamentals upon which the study in the area of specialization is built; but, it must prepare the student for life in general and thus there must be an emphasis on the development of self-reliance and awareness of the interrelation between science, technology and industry and the society in which we live. For this reason, all curricula have a balance of basic material leading into more advanced theoretical and applied treatment of this knowledge with the inclusion of sufficient humanities to make a meaningful education for a productive life. Graduates are prepared to enter industry in the fields they have chosen or to continue for further education in graduate schools in preparation for research, teaching, or industrial positions.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering. The ECPD has also accredited a two-year part-time program in civil engineering technology and a four-year part-time program in civil engineering technology. The chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus

The campus is situated 25 miles north of Boston, Massachusetts, in Lowell, a city of nearly 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 29-acre campus, situated on both sides of the Merrimack river, includes 13 main buildings, among them an auditorium-administration building, a library which is currently being greatly enlarged, six classroom-laboratory buildings, four residence halls and a gymnasium. A $4,500,000 nuclear science center is now in operation.

Alumni Memorial Library

The library, dedicated to Alumni of the Institute who served in World Wars I and II and the Korean conflict, has recently undergone an extensive expansion. The original building, constructed in 1951 by the Alumni Association, now houses the library's rare books, government depository collection, technical reports and a ground floor student activities area. The new addition, which is linked to the original building by means of ramps, houses most of the library functions. The main floor contains the lobby with its control desk, exhibition area, catalog, reserve book room, reference room as well as the administrative and work areas for the library staff. Two elevators serve the library building. The third floor houses the extensive periodical collections, including current issues as well as a microprint area. A section of this floor holds the abstracts and indices that serve as a guide to the periodical collections. The fourth floor houses the science and technology book collection while the

fifth floor houses the collection of the humanities and the social sciences. On each floor shelving areas are mixed in with reading and lounge areas to give maximum accessibility to our collections. The lounge areas on the upper floors provide excellent views of the City of Lowell and the surrounding areas. The ground floor has a complete audio-visual area consisting of a master control room, a student listening room with thirty-one individual stations, six individual listening areas with equipment, an audio-visual office, a multi-purpose room seating 140 and a nine room radio station complex. The building seats approximately 1000 students and has a stack capacity of 450,000 volumes. A walkway under the side of the building adjacent to Smith Hall leads to the first aid station and the dormitory areas located behind the library.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $17,500,-000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, pastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Dean of Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure no less than 12 months in advance of the expected date of enrollment.

The Institute does not accept part time or special students, nor does it accept students at mid-year.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Dean of Admissions, Lowell Technological Institute, Lowell, Mass. 01854.

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is requesting financial assistance must file a Parents' Confidential Statement with the Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.
2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.
3. Submit the entire application form to the office of the secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Dean of Admissions.
4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test during the senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Dean of Admissions prior to completion of the CEEB examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute, a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of a letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll. Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving a final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation. The responsibility for sending this final transcript to the Dean of Admissions Office rests with the student. Failure to instruct his secondary school to forward this final transcript could result in his being not accepted in the fall.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Dean of Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on October 23, 1970, January 8, 1971, February 26, 1971, April 16, 1971, October 29, 1971 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Association of Colleges and Secondary Schools, Inc., the Regents of the State of New York, or a board of equal standing. The New England Association of Colleges and Secondary Schools accredits schools and colleges in the six New England states. Membership in one of the six regional accrediting associations in the United States indicates that the school or college has been carefully evaluated and found to meet standards agreed upon by qualified educators. Colleges support the efforts of public school and community officials to have their secondary school meet the standards of membership.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high school work:

English	4 units
mathematics	2 units
American history and	

social studies	2 units
laboratory science	1 unit
electives	7 units

as well as the Scholastic Aptitude Test. Candidates should also indicate the choice of this program in the space provided on page one of the application.

Advanced Placement

Lowell Technological Institute subscribes to the program of the College Entrance Examination Board providing academic credit for students qualify for advanced standing. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English Proficiency Test and have the results sent to the Dean of Admissions prior to filing a formal application with the Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U.S.A. and, as stated above, request the results be sent to Lowell Technological Institute.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that required of U.S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U.S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U.S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

Transfer Credit Requirements

1. The formal application for all potential transfer credit students to Lowell Technological Institute must be filled out in its entirety. An affirmative answer to Question 6B is a requisite.

2. Completed application forms are considered by the Committee on Admissions. Selection of potential transfer credit students is based entirely on its determination. Successful candidates will receive Form No. 1 application following this decision. Students denied transfer credit will be notified by mail.

3. The prospective student, in completing this form, MUST indicate the curriculum major he intends to pursue at Lowell Technological Institute. Lowell Tech reserves the right to limit assignment of transfer students to specific curricula.

4. The transfer credit applicant should list in Column I our course title, and number all Lowell Tech subjects offered comparable to those *completed* at another college or university. This enumeration should also include such comparable subject titles as are *in progress* or *in contemplation*.

5. Those subjects taken at other institutions of learning should be listed by course title and number in Column II and matched to each one being petitioned for credit appraisal at LTI. Subjects in progress or contemplated for completion must likewise be included.

6. Credit will not be considered in subjects where the applicant's grade is lower than "C", or from an institution granting neither an associate nor bachelor's degree.

7. The third column should include catalogue page number and description of subjects taken at other recognized institutions. The fourth should include text required in the particular subject. The first must show the name of the institution where the applicant studied. *Do not mark Column Six.*

8. All completed information with the most recent transcript (s) and catalogues must be received at Lowell Technological Institute Admissions Office no later than April 1. *There will be no exceptions.*

9. As courses so indicated in Form No. 1 are completed, it is the obligation and sole responsibility of the individual applicant to supply his official transcript record to LTI. Transcripts for subjects ending after the April 1st deadline, must be received by August 1st. The College will not solicit this required information.

10. Students completing the equivalent of one full year of college work, waive the SAT examination requirement. Others must forward official copies of SAT figures from Princeton, New Jersey.

11. One full year of physical education completed at another institution will be considered for transfer credit. This subject is a degree requirement at LTI.

12. Applicants are advised that it is a rule of Lowell Technological Institute that NO CREDITS will be allowed a student after he registers. It is therefore, imperative you list all credits you are hopeful of attaining before registration. After registration, a final decision concerning transfer credit rests with the Department Head in which the student is going to matriculate and the Dean of Admissions.

Re-Admission Policies

Due to the rapidly increasing number of applicants for admission, the problem of considering the application for readmission of a student who has been dropped or withdrawn for scholastic deficiency has become more difficult.

It is clearly evident that the student who has already been given his chance does not have as much right to consideration as the student who is applying for the first time and who may be denied admission by limitation of numbers.

Once a student has formally filed a withdrawal form from the Institute, he must comply with this readmission policy. Therefore, it is the policy of the Admissions Committee that the students leaving for scholastic reasons be required to fulfill the following conditions before their petition will be considered:

1. Students must remain dropped for at least one regular semester.

2. All students desiring consideration for readmission to Lowell Technological Institute must submit pages one and two of our application, completed in its entirety, with a check in the amount of $10.00. A letter giving the original date of entrance to this college and a brief resume of what you have done since you left Lowell Technological Institute must accompany this application. You should list in this resume other schools attended, subjects taken, and grades received. This letter must be addressed to the Dean of Admissions.

3. They must show evidence of improved scholastic ability by enrolling in the courses of some accredited institution and submit good grades in the subjects in which they showed weakness.

These grades under certain conditions may be transferred for credit and also used as evidence of worthiness for readmission. The conditions for which credit will be allowed are listed in the next paragraph. Students must apply for readmission for the entire year if they were freshmen. Only those courses in which C— or better grades have been earned will be omitted. ROTC and Gym can be considered separately. Upperclassmen

may be admitted to repeat the last semester of their failing year or be called upon to repeat the entire year as the situation warrants.

If a student is dropped from the Institute for scholastic reasons and completes the required forms supplied by the registrar's office, which allows him to take subjects at another institution of higher learning, he may petition to have such subjects transferred to Lowell Technological Institute for credit providing that this form has been signed by his Department Head and the Registrar prior to his taking of such subjects. Grades C— or better must be obtained for transfer credit.

5. When all of these items have been received in the Admissions Office, a letter will be sent notifying you of the decision of the Committee on Admissions. No notification will be given by telephone or in person. Applications received after June 1 will not be considered under any conditions for admission to the Institute in September of that year. Only in very rare cases are students considered for readmission in February. If, however, in the opinion of the Dean of Admissions, a student can be phased into his program of study with benefit to the student, application and credentials must be received prior to January 1 for consideration for the second semester admission.

6. Final decision will be made by the Dean of Admissions as to whether or not readmission would serve the best interests of the student and the Institute. Approval of readmission is not automatic and all decisions will be final.

GED Certificate

In order to encourage and support non high school graduates in their effort to obtain a college education, Lowell Technological Institute recognizes the GED TEST as an instrument to obtain the Massachusetts High School Equivalency Certificate which we in turn honor in lieu of a high school diploma. This applies to applicants from the state of Massachusetts only, and students applying from other states should consult their Department of Education regarding how the GED Certificate is used as an equivalent to a high school diploma.

Lowell Technological Institute adheres to the terms of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) entitled "Nondiscrimination in Federally Assisted Programs," which states:

"No person in the United States shall, on the ground of race, color or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

STUDENT HOUSING AND SERVICES

Residence Halls

All non-commuting male students are required to live in the residence halls on campus insofar as our facilities permit unless excused in writing by the Dean of Students. Excuses are reviewed periodically and may be cancelled should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students. When permission is granted to live off campus, the students must record, in the Dean of Students office, their off-campus local address. Further, the students are obliged to notify the Dean of Students office of any subsequent change during the academic year.

Permission to reside at home is accorded in cases where the student lives within a normal commuting distance from the Institute or where financial hardship would be involved through living in a residence hall.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each student must supply his own sheets, pillow, pillowcases, blankets, towels and personal linens or may subscribe to the laundry service provided for all resident students at a reasonable cost. Each occupant of a room is responsible for damage to furniture, equipment and interior surfaces. In the event of damage to public areas (corridors, lobbies, shower rooms, etc.) the cost will be apportioned among all residents of the building concerned.

No facilities are available for the housing of female students. Those who do not live at home must make arrangements to reside off-campus. A list of off-campus rooms and apartments is supplied by the Housing Office. In the event that rooms for female students should become available on a limited basis, they will be assigned in the order in which applications are received.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application is approved by the Housing Office.

Rental charge for each residence room is made for the full academic year payable upon registration prior to the Fall semester.

Refunds

In the event of withdrawal, a refund may be made only when the following conditions are met:

1. All rooms must first be assigned.

2. When another student of LTI (not originally assigned a dormitory room) takes up *new* residence in the dorm then a refund may be made to a withdrawn student in the order in which the withdrawal took place without regard to a specific room or space.

The Institute reserves the right to reassign or transfer resident students within our dormitory buildings. In the event of such a reassignment or transfer of a student already in residence, the Institute shall not be liable for a refund to the former occupant of the room to which said reassignment or transfer is made.

While the room charge covers occupancy only during periods when the Institute is in regular session it may, at the discretion of the Dean of Students, be extended to include vacation periods under extenuating circumstances.

The Institute reserves the right to utilize student rooms during vacation periods for conferences and other groups or for housing of remaining students in one residence hall for safety reasons.

Residence Hall Regulations

1. The Resident Proctor is available to students by appointment except in the case of emergency. Appointments can be made through the head student proctor. (This regulation may be adjusted depending upon the dormitory).
2. The hours of the First Aid Dispensary, located behind the Library, are from 8:00 a.m. to 5:00 p.m. Report any illness or injury occurring at any other time to a member of the proctor staff.
3. Pets, intoxicating beverages, gambling, weapons of any sort, and narcotics are prohibited on campus.
4. Freshman resident students are not permitted automobiles.
5. Woman guests of dormitory residents may be permitted in the lobby reception areas and parents and relatives may visit the rooms with permission of the Resident Proctor or Head Student Proctor, under individual dormitory conditions.
6. Concerning room conditions:
   a. Students are responsible for the condition of their rooms, its furniture, and equipment. No items of furniture or equipment are to be moved from the rooms.
   b. Students will be assessed for damage or theft of Institute items.
   c. For health reasons, beds should be made daily and rooms must be kept clean.
   d. Electrical appliances such as radios, phonographs, clocks, electrical shavers, tape recorders, etc., are permitted. *Cooking appliances* of any kind are prohibited, as well

as bicycles, auto parts, and motorcycles, from the residence halls.

e. Pictures may be taped to cement walls and wood paneling only; never to plastered walls.

f. Food and juice are permitted in the residence halls, subject to the following three conditions:

1. Food that must be heated before it is consumed is not permitted.

2. Foodstuffs which have objectionable odors, i.e., some cheese and meat items are not permitted.

3. All foods without proper preservatives must be kept in closed containers and consumed within 24 hours. All wrappings, remains of and utensils used for their consumption must be cleaned and/or disposed of immediately.

g. Rooms should be locked when left vacant.

h. Screen must be kept intact on windows and ledges kept clear — nothing may be hung from the windows.

i. Rooms may be inspected by Institute officials or the proctor staff at any time.

j. Students must sweep floors, dispose of all trash, unplug all electrical appliances, and turn off all lights when leaving the residence halls for vacation periods.

k. Light bulbs may be obtained from the floor proctors or building custodians.

l. Signs are not permitted on the outside of the doors.

7. General Dormitory conditions:

a. Students are reminded that they live under group conditions and that acts of thoughtlessness and irresponsibility jeopardize the opportunities of everyone to study and work in the residence halls. When in doubt, be considerate of the other person.

b. Rooms are contracted for the entire academic year, and students are responsible for their room rent regardless of whether they occupy their rooms. No resident student is permitted at any time to maintain housing other than his residence hall assignment. Freshmen are assigned rooms by the Housing Office. Upperclassmen may sign up for the rooms they wish at the Housing Office or designated area. Room changes are permitted only during announced times near the beginning of each semester.

c. Incinerators are located on each floor for disposal of combustible trash. Bottles, cans, and noncombustible refuse is to be placed in the large barrels provided in each incinerator room.

d. Keys are provided for each room. Replacement fee in case of loss is $2.00.

e. In case of emergency, turn on room lights, close windows and leave room with door closed and unlocked, then walk to the nearest building exit.

f. Lost and Found is located in the Office of Security Police, located in the Basement of Cumnock Hall. Deposit any lost items there.

8. Concerning discipline:

Members of the proctor staff will assist students in their orientation to residence hall life, and furnish more details on discipline policies and procedures. Appropriate discipline, in the form of room restriction or other measures, may be taken by the proctor staff toward students who refuse to act in a responsible, mature manner while in the residence halls.

Dining Halls

All students living in the residence halls are required to purchase a dining hall meal ticket. The Leitch Hall dining room is for the use of Bourgeois and Leitch Hall residents. Residents of Smith Hall, Eames Hall, and the Annexes will obtain their meals in the Smith Hall dining room. The contract food service provides two meals a day (breakfast and dinner), seven days a week, at a cost of $190.00 per semester. In the event of withdrawal, the cost of a dining hall meal ticket is refundable in accordance with the Tuition Refund Schedule. This charge is payable upon registration prior to each semester. The Smith Hall dining room is open at noon to provide food service on a cash basis for all students. The Eames Hall Snack bar is open intermittently during the day and evening.

Health Service

Registered nurses are on duty for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with a parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Counselling

The counselling program, under the supervision of the Dean of Students Office, starts with the admissions procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Director of Student Counselling for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Director of Student Counselling.

Due to the large numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the counselling program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Counselling in the upper classes is generally conducted in scholastic matters by the Head of the Department concerned and in personal problems by the Dean of Students office.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE $10

1. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.
2. The application fee is NOT credited to the student's tuition.

TUITION **(per year)**

U. S. citizens who are residents of Massachusetts **$200**

Participants in the New England Board of Higher Education Regional Student Program **$200**

All others **$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U. S. citizens who are residents of Mass. ..**$10.00 per cr. hr.**

All others ....**$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community

claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.

2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.
3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

ROTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND $49

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

Residence Halls

The residence hall room charge is $375 per student, per year. Each resident student will be billed for the entire academic year. In the event a student withdraws or is dropped at any time during the year, he is still responsible for the room charge and will be reimbursed only under the conditions as set forth on page 39

LATE REGISTRATION FEE $25

A student who does not complete his registration (including the payment of all fees) by the close of the registration day assigned must pay this additional fee.

AUDITING FEE .... $5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE $15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES $5

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But Less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition

U.S. citizens who are residents of Massachusetts **$200**

Participants in the New England Board of Higher Education Regional Student Programs **$200**

All others **$600**

Residence halls ....**$375 per student per year**

Student activity and insurance fee ....**$ 49**

ROTC deposit ....**$ 25**

Books, supplies, and related miscellaneous expenses (approximate) **$100**

The Boarding fee is $380 per student, per year.

The Board of Trustees reserves the right to change any or all fees without prior notice.

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Attendance

An excused absence system is applicable. For regulations consult the KEY (Student Handbook).

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(53-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester. Refer to THE KEY (Student Handbook) for method of calculation.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

PROBATION AND DISMISSAL — ACADEMIC

Probation

A student is automatically placed on probation under the following conditions:

A. When the student's semester rating is less than 1.35

B. When the cumulative rating of a student not on probation is less than the appropriate value

Freshman Year-end	1.40
Sophomore Mid-year	1.45
Sophomore Year-end	1.50
Junior Mid-year	1.55
Junior Year-end	1.60
Senior Mid-year	1.65

The probationary period covers the entire regular semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the institute in any public function or extracurricular activity and may not hold or run for any class or other offices during the term of probation, and is allowed no unexcused absences from classes.

Dismissal

A student is automatically dropped from the Institute for at least one semester under the following conditions:

A. When the student's semester rating is below 0.70

B. When the student's semester rating is less than 1.35 for two consecutive semesters

C. When the student, while on academic probation, fails to achieve the cumulative rating required in Item B above, effective with the Class of 1972.

Upon request of a student who has been notified of impending academic dismissal from the Institute by the above conditions, the Dean of Students, in the case of a freshman, and the appropriate Department Head, in the case of an upperclassman, will grant the student a hearing to review that student's case to ascertain if extenuating circumstances exist which would justify further consideration.

A student dropped from the Institute must take subjects at some other college before applying for readmission to LTI.

PROBATION AND DISMISSAL — DISCIPLINARY

A student is placed on disciplinary probation by the Dean of Students when in his opinion a student has violated a basic rule of conduct or an established rule of the Institute. The probationary period covers the entire semester in which the violation took place. The length of time of the censure can be a longer period of time.

A student who violates the basic tenet of disciplinary probation may be dismissed from the Institute.

If the original violation is of a serious nature, the Dean of Students may dismiss the student without benefit of a probationary period.

Any student on disciplinary probation may not represent the Institute in any public function or any other extra-curricular activity and may not hold or run for any class office or other office during his term of probation, nor is he allowed to cut any classes or laboratory sessions.

RULES OF CONDUCT

The Board of Trustees recognizes the dual obligation of the Institute to insure the orderly pursuit of its proper functions at all times while preserving the rights of individuals and groups to freedoms guaranteed by our national and state constitutions and normally prevailing in the academic community. The Board of Trustees recognizes and defends the right to open discussion, the right to hold and articulate one's own beliefs and convictions, the right of peaceful assembly, the right to petition, the right to distribute handbills and circulars, the right to a fair hearing, and such other rights as are inseparable facets of the concept of academic freedom and are indispensable for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. The basic distinction to be made is that between those activities which are consistent with our obligation as an academic institution dedicated to free inquiry and free expression and to safeguarding the freedom to teach and the freedom to learn and those activities which are inconsistent with this obligation. It follows that there is a responsibility for the Institute to draw clear distinctions between conduct on the part of members of the Institute community and visitors to the Institute which is acceptable and that which is not. The rules set forth below are effective in accordance with the existing laws of the Commonwealth and the nation.

The following activities are among those which are considered unacceptable because of their adverse effect on the preservation of freedom or on the orderly pursuit of Institutional work:

1. Obstruction or disruption of teaching, research, administration, or other Institute activities, including the Institute's public service functions or of other authorized activities, on Institute owned or controlled property;

2. Obstruction of the free flow of traffic, both pedestrian and vehicular, on Institute owned or controlled property;

3. Physical abuse or detention of any person on Institute owned or controlled property or at any Institute sponsored or supervised functions, or conduct which endangers the health or safety of any person;

4. Theft of or damage to property of the Institute or of property of a member of the Institute community or the property of a visitor to the Institute;

5. Unauthorized entry to or use of Institute facilities, including both buildings and grounds;

6. Violation of Institute established policies or regulations, including regulations in the Catalogue, the "Key" and other publications pertaining to student organizations, student, faculty, administrative staff, non-academic employees and visitors conduct, the use of Institute facilities, or procedures concerning the time, place and manner of public expression;

7. Violation of rules governing residence in Institute owned or controlled property;

8. Use, possession, or distribution of narcotic or illegal drugs on Institute owned or controlled property, except as expressly permitted by law;

9. Failure to comply with directions of Institute police and any other law enforcement officers acting in performance of their duties and to identify one's self to these officers when requested to do so;

10. Illegal or unauthorized possession or use of firearms, explosives, dangerous chemicals or other weapons on Institute owned or controlled property;

11. Failure to comply with the directions of Institute officials acting in the performance of their duties;

12. Disorderly conduct, breach of the peace, and aiding, abetting or procuring another to breach the peace on Institute owned, or controlled property or at Institute sponsored or supervised functions.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors — graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors — graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors — graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Defense Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates, through the College Scholarship Service, Princeton, New Jersey.

Students may obtain applications and information regarding these programs at the Financial Aid Office, O 112.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of $500 to a freshman entering the Institute is made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships

The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200,

and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

AFROTC College Scholarship Program

High school students desiring information on the 4-year AFROTC College Scholarship Program should see their school guidance counsellor or write directly to AFROTC (ARTO-O/TA), Maxwell AFP, Alabama 36112 for further information. Normal deadline for application is 15 November each year.

Scholarships are provided on a competitive basis to a limited number of cadets entering aerospace studies 200 — 300 — 400 in the Air Force ROTC four year program. The grant covers full tuition costs, books, laboratory expenses and incidental fees. A grant earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable standards. Cadets also receive $50 per month subsistence allowance.

Greater Lowell Home Builders Association

This organization has established a $200 scholarship for a deserving resident of Greater Lowell. The scholarship will be renewable for four years on the condition that satisfactory grades are maintained.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-Down, the televised science quiz for Massachusetts eighth-grade pupils, co-sponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities

where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass., West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

Outside Scholarship Assistance:

The Afro-American Society at L.T.I. has compiled a list of Private, Public, and Federal Scholarships, Funds, Fellowships, and Loan Programs that are available to disadvantaged persons.

The Financial Aid Office has copies of this list which will be sent upon request. Correspondence should be addressed to the Director of Financial Aid, Lowell Technological Institute, Lowell, Massachusetts 01854.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Foundation Scholarships

Two grants of $750, given by the Allied Chemical Corporation, are awarded to worthy students majoring in Textile Chemistry or Textile Engineering.

S.M.E. Awards

Merrimack Valley Chapter 113, Society of Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The S.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

Boston Paper Trade Association Awards

Two awards, each for $200, are open to upperclassmen enrolled in the Paper Engineering Department. Awards are based on character, proven interest in the Paper Industry and academic performance.

The Chemical Club of New England Scholarship

This scholarship in the amount of $400 is awarded to a

student in Chemical Engineering or Chemistry who is a resident of New England. Selection is based on ability and financial aid.

Chemstrand Corporation Scholarship

A scholarship of $500 is available to a superior, deserving student enrolled in textiles. Donor is the Chemstrand Corporation.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton, Pa., has established a scholarship in the amount of $500 per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarships

The Foster Grant Company, Inc., of Leominster, Mass., makes available on a one-year basis two scholarships to deserving students in Plastics Technology who are residents of Massachusetts. Preference is given to sophomores living in the Leominster area; however, if there are no applicants from that area, other candidates may be chosen. Scholarship, personality, and overall student contribution to extracurricular activities are the general criteria used in selecting the recipients.

Roland E. Derby, Sr. Memorial Scholarship

This Scholarship established in memory of Roland E. Derby Sr. provides a $500 scholarship to a sophomore student who is a candidate for a degree in Chemistry, Textile Chemistry, or Chemical Engineering. Selection by the Scholarship Committee shall be based on scholastic achievements, but due consideration shall also be given to financial need. The scholarship shall be renewable for the Junior and Senior year provided the recipient maintains a satisfactory academic record.

General Electric Scholarship

The General Electric Company has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics Technology.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two $250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, Plastics Technology, or Textile Chemistry who have proved themselves scholastically and who are active in extracurricular programs.

Paper Engineering Department Scholarships

Ten or more scholarships with annual stipends of $500 are available to upperclassmen and selected graduate students in Paper Engineering who fulfill the scholarship requirements of a minimum of 2.0 cumulative rating. These scholarships are normally maintained from year to year provided the student maintains his academic rating.

Present contributors to the Scholarship Fund include the following:

Bertrand Hopper Memorial Fund
Byron Weston-Crane Company
Carter Rice Storrs and Bement, Inc.
Weyerhaeuser Company
Dennison Manufacturing Company
Erving Paper Mills
Fitchburg Paper Company
Fraser Paper, Ltd.
Hollingsworth and Vose
International Paper Company
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Tileston and Hollingsworth
S. D. Warren Div. Scott Paper Company

Mobay Scholarship

The Mobay Chemical Company of Pittsburgh, Pennsylvania has made available on a one-year basis a scholarship to be awarded to a deserving upperclassman majoring in Plastics Technology.

Society of Plastics Engineers Scholarships

Two scholarships are granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to upperclassmen majoring in Plastics Technology.

Uniroyal Incorporated

This Foundation has established scholarships for students who have successfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value.

Applicants must be in need of financial assistance, and recipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry or Textile Chemistry in the amounts of $225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

Available to Undergraduate & Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3% beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemiestry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

SME Award. The Merrimack Valley Chapter, Society of Manufacturing Engineers awards $100 to a member of the Student Chapter of the SME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and

extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a highl evel of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member out-

standing for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

The Wall Street Journal Student Achievement Award

This award recognizes the senior in Business Administration or Industrial Management who has achieved the best combination of academic and extracurricular excellence. The award consists of an engraved paperweight, a year's subscription to the Wall Street Journal, and a plate on the permanent plaque established for the award winners.

OTHER ASSISTANCE FOR MASSACHUSETTS
Residents Only

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upperclassmen. For full information write to:

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1,000 a year for undergraduate school, or $1,500 a year for graduate school. There is no interest charge on such loans while the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 7% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Massachusetts 02116
Telephone 426-9434

Cooperative Study Program

The First Naval District has approved Lowell Technological Institute as Sponsor of its Cooperative Work-Study Program at the Boston and Portsmouth Naval Shipyards.

Students will undertake a five-year program in their field of specialization - electrical, electronic, chemical, civil and mechanical engineering, increasing their experience and capabilities in subsequent on-the-job training at either shipyard. Successful students will earn the bachelor of science degree.

Information concerning this program may be obtained by writing the First Naval District Headquarters at Charlestown or the Director of Admissions, Lowell Technological Institute.

PLACEMENT

Industrial Training Program

The Placement Office maintains two basic functions. One is to counsel the senior planning to take recruiting interviews; the other is arranging the dates of interviews for the representatives of the recruiting companies and agencies.

In the counselling process the Placement Officer reviews the student's transcript with him, discussing his points of strength and weakness. The elements of the recruiting procedure are explained so that he may be properly prepared for the ensuing interviews.

Approximately one hundred and eighty companies and government agencies recruit on the LTI campus. The companies represent a cross-section of industry in the country ranging from the so-called giants down to those of relatively small size. Geographically, they are located in the Northeast, the Southeast and the Mid-West with a few from the Far West. Thus, the seniors get fairly broad exposure to business opportunities.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit subjects for college students who require deficiency clearance or who seek advanced standing; and Precollege Refresher subjects for incoming freshmen at LTI.

The industry-sponsored professional advancement program comprises a series of specialized intensive, one- to three-week courses. The two six-week undergraduate sessions stress fundamental credit offerings in college mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

Precollege Refresher Program

The Precollege Refresher Program is especially designed for prospective LTI students who require additional background to fulfill minimum entrance requirements. Students must first apply for fall admission; the Dean of Admissions designates the subject or subjects required for coverage of minor deficiencies in the high school background. Five-week, noncredit subjects in basic mathematics, physics, chemistry, and English are offered in a June-July session to accommodate all freshman candidates.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

THE GRADUATE SCHOOL

The Lowell Technological Institute Graduate School, which was founded in 1935, offers advanced studies, including professional training and research leading to graduate degrees in many fields of engineering and in certain areas of pure and applied science. The School offers Master of Science degree programs in the following fields: Chemical Engineering, Chemistry, Electrical Engineering, Mathematics, Mechanical Engineering, Nuclear Engineering, Paper Engineering, Physics, Plastics, Polymer Science, and Textile Technology. Programs leading to the Doctor of Philosophy are also offered in Chemistry, including a Polymer Science option, and in experimental and theoretical Physics, including Solid-State, Nuclear, High Energy, Atomic, Atmospheric and Biophysics options. In addition to the day classes intended primarily for full-time graduate students, the Graduate School offers some evening courses through the Division of Evening Studies mainly for the convenience of part-time students primarily interested in advanced professional training. The courses offered in the evening are equivalent in every respect to those offered to the day students for they are simply evening sections of courses offered during the day. There are currently 129 graduate students enrolled in degree programs for advanced professional training in these Evening Division courses out of a total Graduate School enrollment of 328 students. These part-time students are primarily from the large industrial companies nearby the Institute located principally in the Merrimack Valley. New graduate programs in Applied Mathematics, Computer Engineering, and Electronic Systems Engineering are currently under consideration by the Graduate School Executive Committee and it is hoped that these programs will be instituted in the Fall of 1970. Programs of this type, which would include as well as Computer and Systems Engineering, the graduate program in Plastics, Paper, Textiles and Nuclear Engineering are in wide demand by industry in New England and in Massachusetts in particular. These programs serve as excellent supplements to the standard curricula in the basic engineering and science areas which would include Chemistry, Physics, Chemical Engineering, Electrical Engineering and Mechanical Engineering. In June of 1969, there were 31 Master of Science degrees and 2 Doctor of Philosophy degrees granted through the Graduate School at LTI. For further information concerning the graduate programs, please consult the Graduate School Catalog.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;

Guidance work in the high schools;

Technorama, science fair for area high schools;

Consultive opportunities with the faculty;

Collaboration with the Agency for Internationla Development of the government in its foreign aid program;

Special radio and television programs, such as Science

For information relative to these programs, address the Coordinator of Special Services at the Institute.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers Undergraduate Programs leading to Associate and Baccalaureate Degrees, and Master's Degree satellite programs with area industries. The majority of the degree programs are in the fields of science, engineering technology and business administration. Additionally, individual subjects in mathematics, science, technology, engineering, and general studies may be taken by special arrangement. Selected subjects offered during the summer are conducted as part of the Professional Advancement Program.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers In-Service Training Programs limited to employees of the Commonwealth and cities and towns within the Commonwealth. These undergraduate programs lead to Associate and B. S. degrees in Civil Engineering Technology, Associate in Business Administration (in either Accounting or Data Processing), and Bachelor in Business Administration. The Associate and B. S. Degree programs in Civil Engineering Technology are accredited by the Engineers' Council for Professional Development.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established in 1950 for the purpose of conducting research, development and testing under government and industrial sponsorship. Initially its prime purpose was to answer the needs of the Lowell Technological Institute for facilities and staff to perform basic and applied research in textiles and related subjects. As the Research Foundation expanded, a diverse and growing program of research and development activities has increased extensively, and projects have moved into the fields of chemistry, leather, paper, plastics, electronics, physics, and more recently, oceanography, nuclear engineering and environmental pollution, in addition to management and economic development assignments.

They keynote of operation of the Research Foundation has always been its flexibility and consequent versatility in tackling diverse problems, in cooperation with the staff and faculty members of Lowell Technological Institute. The Research Foundation is presently composed of four major divisions, Electronics and

Physics, Environmental Pollution, Ionospheric Science and Testing Divisions, the latter being mainly concerned with the testing and evaluation of textiles and a wide variety of other materials submitted by industry and government sources.

One of the major research activities of the Research Foundation is in the field of geophysics, with particular emphasis on ionospheric characteristics deduced from ionosonde and satellite total electron content measurements, and spaced receiver experiments to investigate F-Region irregularities. Very intensive theoretical and experimental work has been carried out in the lower levels (D-Region) of the earth's ionosophere.

Another field of considerable interest and proven capability is in the area of optical physics. Specific research programs have included investigations in atmospheric optics, photographic sciences, spectrographic analysis and electro-optical instrumentation technology. Recent experimental and theoretical studies have considered the problems associated with imaging through a turbulent atmosphere using both coherent and incoherent illumination.

Design, development and fabrication of instrumentation systems for scientific and industrial use is conducted within the organization by the Systems Engineering Group. New circuit and measurement techniques are evaluated for suitable applications which include rocket payloads, telemetry ground stations, oceanographic and high altitude balloon instrumentation.

The Environmental Pollution Division within the Research Foundation has undertaken research in the ever widening field of pollution abatement, together with investigation of relevant chemical and engineering problems.

The Merrimack Valley Industrial Information Center is a new facility operated by the Research Foundation. The Center was established to assist in the economic development of the Merrimack Valley Area of Massachusetts by providing access to the vast source of technological, economic and business information available in the United States.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four executive officers elected by the student body and the officers of each class. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Amateur Radio Club

This organization is enjoined to promote the fraternity of Amateur Radio at Lowell Tech and specifically to promote the fellowship of amateur radio through on-the-air activities. To aid interested individuals in obtaining their amateur radio license as well as helping current license holders advance their grades.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier current radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition has extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multipurpose room and radio studios.

WLTI was originally organized as The Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10 Kw FM transmitter. Work is now under way on the renovation of this equipment and the licensing of the

station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Cheerleaders

The Cheerleaders encourage and promote the enthusiasm of the Student Body as well as that of the team members at L.T.I. basketball games.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Students Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interests and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen. They are also responsible for publishing the student handbook, THE KEY.

Interdormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a

liaison between residents and the administration to maintain proper deportment and living conditions.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

There are fraternities — Delta Kappa Phi, Kappa Sigma, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, Sigma Phi Omicron, and Tau Kappa Epsilon — all have their own fraternity houses. All provide social life off campus and four are national fraternity affiliates. The Inter-fraternity Council fosters the common interests of the seven and sponsors interfraternity social and athletic events.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Karate Club

Instruction in Karate is made available to members of this organization.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its student staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Association for Textile Technology, Student Chapter
- American Chemical Society, Student Chapter
- American Meteorological Society, Student Chapter
- American Nuclear Society, Student Chapter
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemical Engineering Society
- Civil Engineering Society
- Industrial Management Society
- Institute of Electrical and Electronics Engineers, Student Chapter
- MALTI (Mathematics Association of LTI)
- Sigma Kappa Psi
- Society for Advancement of Management, Student Chapter
- Society of Physics Students
- Society of Plastics Engineers, Student Chapter
- TAPPI (Student Chapter, Tech. Association of Pulp & Paper Industry)

Religious Groups

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel.

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Community

Through the combined efforts of the spiritual advisors and many local friends, the Newman Community now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI, Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Afro-American Society

This organization assists and organizes whatever separate groups and/or function that will allow those individuals dedicated to the benevolent welfare of black people to invest their energies.

Sororities

BETA TAU Sorority was recently established on campus to promote good fellowship and high scholarship. As a service

sorority, BETA TAU participates in many campus and community activities.

PHI SIGMA RHO, established in 1937, is the oldest sorority on campus. Its members enjoy the bonds of sisterhood as well as take an active part in social, civic, and recreational activities.

Sports Car Club

This club promotes the safe, courteous, efficient, and skill-full operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-monthly publication offers excellent journalistic and business experience to those who work on its staff.

Vandenberg Air Squadron of the Arnold Air Society

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and aerospace exhibits during the year. The Military Weekend, annual highlight of its program, is climaxed by the formal Military Ball at which time new members are accepted into the society.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

Veterans Club

The objectives of this club shall be to present programs of interest and importance to the membership of the club, to service all veterans whether or not they are members of the organization, to assist members in finding part-time and summer employment, and to actively participate and become interested in academic and non-academic areas of concern within the Institute.

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC) the first two college years and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Four-Year AFROTC Program or the Two-Year AFROTC Program. A student electing the Four-Year Program will take the General Military Course during his freshman and sophomore years and the Professional Officer Course during his junior and senior years. He will attend four weeks of field training during the summer between his junior and senior years. As a member of the Four-Year Program he is eligible to compete for an AFROTC Scholarship. For acceptance into the POC, the Four-Year Program student must pass a physical examination, an Officer Qualification Test, and possess an acceptable academic rating. To qualify for enrollment in the Two-Year Program, a student must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. He must also meet certain physical standards, pass an Officer Qualification Test, and possess an acceptable academic rating. Further, he must successfully complete a six-week Field Training Course before he can be accepted into the Professional Officer Course. Students in the Two-Year Program are not eligible to compete for AF-ROTC Scholarships. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the Institute and the United States Air Force. Students in the Professional Officer Course receive a $50.00 a month subsistence fee. Additionally, scholarships are available to a limited number of cadets in the 4-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify may receive further training after commissioning in scientific skills, pilot or navigator training, or administration. Outstanding seniors who are designated Distinguished AFROTC Cadets may apply for regular commissions.

GENERAL MILITARY COURSE

FRESHMAN YEAR

		First Semester	
AS	101	World Military Systems I	(1-1) 1
		Second Semester	
AS	102	World Military Systems II	(1-1) 1

SOPHOMORE YEAR

		First Semester	
AS	201	World Military Systems III	(1-1) 1
		Second Semester	
AS	202	World Military Systems IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

		First Semester	
AS	301	Growth and Development of Aerospace Power I	(3-1) 3
		Second Semester	
AS	302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

		First Semester	
AS	401	The Professional Officer I	(3-1) 3
		Second Semester	
AS	402	The Professional Officer II	(3-1) 3

The AFROTC program is recognized as academic but of a highly specialized nature. It is not a requirement for graduation and students may not use more than six (6) credit hours of the Professional Office Course (junior and senior year subjects) in substitution for other subjects taken for graduation. Subjects taken in the ROTC program in the freshman and sophomore years are to be taken in addition to all other subjects listed in the various curricula. Academic credit is given for all ROTC

subjects taken and passed and the grades will affect the student's academic rating. Unless otherwise specified in the section on each curriculum, the six credit hours of advanced ROTC may be substituted for General Electives. For the most part, the allowable substitution of the six ROTC credits for other credits can be made only in the senior year. Business Administration is the only exception to this regulation (refer to Business Administration curriculum's Elective Course Guidelines for all BA Options for details).

CORPS TRAINING

Corps Training is conducted one hour each week. This is an assembly of the entire cadet corps under the direction of the cadet officers and staff wherein the General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to lead, supervise and command marching troops.

FIELD TRAINING

Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $138.00 for the four week Field Training and $131.00 for the six week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot Training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of dual and solo flight instructions at government expense.

CADET DECORATIONS AND AWARDS

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the "Air Force Times" Award, and the Vandenberg Cup.

In addition, the Department of Aerospace Studies confers several medals and awards, among them the Distinguished Military Cadet Award, for outstanding performance in various fields.

Distinguished AFROTC Graduate Awards, based on academic and military achievements, are given to outstanding graduates. These awards constitute an advantage in competing for a Regular Air Force commission.


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ATHLETICS AND RECREATION

Athletics are a part of the total program at Lowell Tech, and essential to the overall development of the individual. New and extensive facilities and a competent professionally trained staff provide numberless opportunities for students to participate in a variety of activities.

A beautiful new, well-equipped physical education building includes a gymnasium, with a seating capacity of two thousand, an all-purpose gym of equal size to the main gymnasium, a collegiate style swimming pool, a wrestling and judo room, weight training facilities, a gymnastics area, two handball and three squash courts, home and visiting team dressing rooms, a modern rifle range, and locker rooms for students and faculty with more than two thousand lockers available.

New athletic fields and a skating rink are located in the area adjacent to the physical education building.

Plans are underway to construct an Intercollegiate Boathouse for L.T.I. on the Merrimack River in Lowell.

The Athletic Association is funded by student fees and provides extensive opportunities for student participation in Intercollegiate, Intramural and Recreation programs. All students are members of the Association and are admitted free to all home athletic contests.

Intercollegiate Athletics: Lowell Tech has intercollegiate competition in seventeen sports. Teams are scheduled in Soccer and Cross Country in the Fall; Basketball, Hockey, Wrestling, Gymnastics, Swimming, Skiing, Squash, Bowling and Rifle in the Winter; Baseball, Track, Golf, Tennis, Crew and Lacrosse in the Spring.

Intramurals: The Intramural program at L.T.I. is extensive. The three leagues — Fraternity, Dormitory, and Independent — compete in the following activities: Touch Football, Tennis, Golf, Bowling, Track, Cross Country, Ice Hockey, Speed Skating, Handball, Squash, Volleyball, Badminton, Water Basketball, Table Tennis, Six-Man Soccer, and Six-Man Lacrosse.

Recreation: The athletic facilities at L.T.I. are open for student use from 9:00 a.m. to 9:30 p.m. weekdays, and from 10:00 a.m. to 3:00 p.m. on Saturdays.

There are opportunities for student participation in the organized and informal recreational activities listed as follows: Badminton, Volleyball, Basketball, Physical Conditioning, Swimming, Diving, Water Basketball, Life Saving, Archery, Table Ten-

nis, Touch Football, Skin and Scuba Diving, Wrestling, Judo, Karate, Rifle and Pistol Shooting, Weight Training, Gymnastics, Handball, Squash, Tennis, Ice Skating, Track and Field, Softball, and Lacrosse.

Equipment needed for most of these sports is available from the Issue Room on presentation of the student's ID card.

Students are urged to supplement their required activities with a regular program of recreation.

PHYSICAL EDUCATION

Physical education makes its contribution to the total college curriculum through specific programs of conditioning exercises, self-testing activities, sports, recreational games, gymnastics, rhythms, aquatic activities, and personal defense activities such as wrestling, judo, and karate. Physical Fitness testing is included as a basic part of the program. The students are expected to become familiar with and develop efficiency in a variety of activities especially team games, individual recreational sports, swimming, and physical fitness.

The classes meet twice a week and are required for the Freshmen. Lowell Tech students must pass a swimming test and four quarters of Physical Education. Each quarter is half a semester. Students who satisfy minimum requirements in the swimming and the Physical Fitness Test are allowed to choose any activity which the Department offers. A new activity must be chosen each quarter.

Students who do not satisfy the minimum requirements are assigned a swimming or a Physical Fitness class. At the end of the quarter, these students are retested.

The program is elective for sophomores, juniors, and seniors. After completing the freshman requirement, they may choose those activities in which they wish to receive additional instruction. Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, physical education credit will be given for such participation.

The following objectives serve as guides for the entire program:

1. The improvement of health through increased organic vigor.

2. The development of efficient and effective sports-skills and motor fitness.

3. The development of desirable social attitudes and standards of conduct.

4. The development of an appreciation for an interest in physical activities which will result in continued participation in wholesome and enjoyable leisure pursuits.

I INDIVIDUAL ACTIVITIES

P.E. 110	Physical Fitness
P.E. 112	Golf
P.E. 115	Individual Sports (handball-squash-paddle racquets)
P.E. 120	Weight Training
P.E. 125	Gymnastics
P.E. 126	Badminton
P.E. 116	Tennis

II TEAM ACTIVITIES

P.E. 130	Basketball
P.E. 135	Hockey
P.E. 136	Skating
P.E. 140	Soccer
P.E. 145	Softball
P.E. 150	Touch Football
P.E. 155	Volleyball
P.E. 156	Indoor Team Games

III AQUATICS

P.E. 160	Swimming for Beginners
P.E. 161	Intermediate Swimming
P.E. 162	Pre Life-saving
P.E. 163	Life Saving
P.E. 164	Competitive Swimming
P.E. 165	Competitive Diving
P.E. 166	Water Basketball
P.E. 167	Water Polo
P.E. 168	Advanced Diving
P.E. 230	Scuba Club

IV COMBATITIVES

P.E. 170	Judo
P.E. 172	Karate
P.E. 175	Wrestling

V INTERCOLLEGIATE SPORTS

P.E. 400	Baseball
P.E. 405	Basketball
P.E. 470	Bowling
P.E. 200	Crew
P.E. 428	Cross Country
P.E. 410	Golf

P.E. 432	Gymnastics
P.E. 415	Hockey
P.E. 460	Lacrosse
P.E. 320	Riflery
P.E. 425	Soccer
P.E. 420	Skiing
P.E. 340	Squash
P.E. 465	Swimming
P.E. 430	Tennis
P.E. 320	Track
P.E. 435	Wrestling

UNDERGRADUATE PROGRAMS

Sixteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Biological Sciences	Mechanical Engineering
Business Administration	Meteorology
Chemical Engineering	Nuclear Engineering
Chemistry	Paper Engineering
Civil Engineering	Physics
Electrical Engineering	Plastics Technology
Industrial Management	Radiological Health Physics
Mathematics	Textile Engineering

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students.

A special curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering is open as an In-Service Training Program for employees of the Commonwealth of Massachusetts and its political subdivisions. Regulations for entrance into this program and subjects required prior to attending day classes as in-residence students are shown in the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

Four-year curricula leading to the degree of Bachelor of Science in Engineering Technology are in the process of being developed in most of the above fields of engineering. Announcements will be made when they become available.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and average number of hours in laboratory; after the parentheses, number indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits.

Some undergraduate subjects may be taken for graduate credit. Consult the Graduate School catalogue for details.

THE ELECTIVE SYSTEM

In all curricula an opportunity is given the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

Prior to the registration period for each semester, a list of the General Electives to be offered is made available to faculty and students. *To ensure fulfillment of degree requirements and accreditation standards, all General Elective choices must be approved by the Department Head or the Advisor in the curriculum in which the student is a degree candidate.*

Subjects taken in the United States Air Force ROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects taken in the junior and senior years in the ROTC program may be substituted for General Electives up to a maximum of 6 credits in all curricula *unless otherwise specified.* In most curricula this substitution can be made only in the senior year.

EC 302	Labor Economics	(3-0)3
EC 303	Microeconomic Theory	(3-0)3
EC 304	Macroeconomic Theory	(3-0)3
EC 402	Government and Business	(3-0)3
EC 403	International Trade Theory	(3-0)3
EC 404	Comparative Economic Systems	(3-0)3
EC 407	Econometrics	(3-0)3
EC 408	History of Economic Thought	(3-0)3
EC 410	Economic Development of Less Developed Countries	(3-0)3
EC 412	Managerial Economics	(3-0)3
EC 414	Engineering Economy	(3-0)3
LL 209	Technical and Scientific Communication	(3-0)3
LL 213	Introduction to English Literature: To 1865	(3-0)3
LL 214	Introduction to American Literature: From 1865	(3-0)3
LL 215	Introduction to American Literature: To 1798	(3-0)3
LL 216	Introduction to English Literature: From 1798	(3-0)3
LL 218	Negro-American Literature	(3-0)3
LL 233	Comparative Literature	(3-0)3

LL 234	Shakespeare	(3-0)3
LL 259-260	Elementary German	(3-0) (3-0)6
LL 261-262	Elementary Technical German	(3-0) (3-0)6
LL 263-264	Elementary French	(3-0) (3-0)6
LL 265-266	Elementary Russian	(3-0) (3-0)6
LL 267-268	Elementary Spanish	(3-0) (3-0)6
LL 269-270	Elementary Modern Greek	(3-0) (3-0)6
LL 311	Advanced Composition	(3-0)3
LL 313	Introduction to Continental Literature	(3-0)3
LL 314	Continental Literature Since the Renaissance	(3-0)3
LL 315	Myth and Symbol in Literature	(3-0)3
LL 316	The English Bible as Literature	(3-0)3
LL 333	Problems of Philosophy	(3-0)3
LL 341	Satire	(3-0)3
LL 344	Modern Poetry	(3-0)3
LL 345	Modern Irish Literature	(3-0)3
LL 363-364	Intermediate French	(3-0) (3-0)6
LL 365-366	Intermediate Literary and Conversational Russian	(3-0) (3-0)6
LL 367-368	Intermediate German	(3-0) (3-0)6
LL 369-370	Intermediate Spanish	(3-0) (3-0)6
LL 435	English Literature of the Eighteenth Century	(3-0)3
LL 436	English Romantic Poets	(3-0)3
LL 437	English Literature of the Victorian	
LL 444	Period	(3-0)3
	Popular Culture	(3-0)3
LL 467	Seminar in German Masterpieces	(3-0)3
LL 471	The Modern American Novel	(3-0)3
LL 472	The Modern British Novel	(3-0)3
LL 473	World Drama	(3-0)3
LL 474	Modern Drama	(3-0)3
LL 476	Nineteenth-Century British Novel	(3-0)3
LL 482	The American Short Story	(3-0)3
LL 495	Reading and Research	(3-0)3
SS 223	The United States: 1865-1912	(3-0)3
SS 224	The United States: 1912 to the Present	(3-0)3
SS 225	Europe: 1789-1914	(3-0)3
SS 226	Europe: 1914 to the Present	(3-0)3
SS 235	England: Roman Times to the Restoration	(3-0)3
SS 236	England: The Restoration to the Present	(3-0)3
SS 301	Government of the United States	(3-0)3

SS 302	Conduct and Control of Foreign Policy	(3-0)3
SS 303	Psychology	(3-0)3
SS 305	Sociology	(3-0)3
SS 307	Seminar in Sociology	(3-0)3
	American Civilization to 1865	(3-0)3
SS 403	Psychological Warfare	(3-0)3
SS 451	History of France	(3-0)3
SS 459	World Politics: The Central Problem of War	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	Defense Policy	(3-0)3
SS 477	Russia: The Empire	(3-0)3
SS 478	Russia: The Soviet Union	(3-0)3
SS 479	The Far East Since 1842	(3-0)3
SS 480	Modern China: 1644 to the Present	(3-0)3
SS 481	The Greeks and Western Civilization	(3-0)3
SS 482	The United States: Urban History	(3-0)3
SS 483	The Development of Western Civilization: To 1789	(3-0)3
SS 484	The Development of Western Civilization: Since 1789	(3-0)3
SS 485	Modern Governments of Europe	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-0)3
SS 489	Political Parties in the United States	(3-0)3
SS 492	Modern Germany	(3-0)3
SS 494	England: The Empire Since 1793	(3-0)3
SS 495	The Technological Future: The Material Aspects	(3-0)3
SS 496	The Technological Future: The Social and Political Aspects	(3-0)3
SS 497	Seminar: History or Political Science	(3-0)3
SS 499	Science and Religion: Science As a Social System	(3-0)3
SS 500	Science and Religion: Religion As A Social System	(3-0)3
SS 501	Afro-American History	(3-0)3

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration* or Industrial Management,** take the following subjects:

First Semester

CH	001	Chemical Principles	(4-0)3
CH	003	Chemical Principles Laboratory	(0-2)1
LL	111	English I	(3-0)3
MA	103	Calculus I	(3-0)3
PH	101	Physics	(4-1)4
		Total hours	(14-3)14

Second Semester

CH	022	Chemical Principles	(4-0)3
CH	004	Chemical Principles Laboratory	(0-2)1
LL	112	English II	(3-0)3
MA	104	Calculus II	(3-0)3
ME	104	Design Graphics	(1-0)1
PH	102	Physics	(4-2)4
		Total hours	(15-4)15

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given for the physical education program.

*The freshman program in Business Administration is given on the page outlining the curriculum.

**Majors in Industrial Management substitute EC 201, Economics 1(3-0)3, for CH 001 and CH 003, and EC 202, Economics II (3-0)3, for CH 002 and CH 004.

Students who elect to take the four-year AFROTC program must take the first two years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the junior and senior years may be substituted for other subjects. See the sections of the catalogue describing the individual curriculum, and the section on AFROTC for further details.

BIOLOGICAL SCIENCES

The curriculum in the Biological Sciences is designed to provide a sequence of liberal arts and science courses for a sound career foundation. Development of attitudes along with abilities is considered highly significant for a successful career. The importance of a breadth of knowledge and understanding of related scientific disciplines is stressed for greater appreciation and comprehension of biological principles and modern quantitative concepts.

Upon graduation the biology major will find opportunities in teaching, industry, government and the medical services. The curriculum objectives chosen permit a sound preparation for graduate study in the biological sciences, medicine and dentistry.

A written comprehensive examination is required of all majors. Students who have demonstrated high scholastic ability may conduct independent studies throughout the senior year. Emphasis is placed on completion of an original research project followed by an oral examination of the candidate's major courses and undergraduate thesis.

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(13-9)15

Second Semester

BI	202	Principles of Biology	(3-3)4
CH	222	Organic Chemistry	(3-4)4
MA	383	Statistical Methods	(3-0)3
		Two General Electives*	(6-0)6
		Total hours	(15-7)17

*LL 334 (Problems of Philosophy) and
SS 304 (Psychology) are recommended.

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
BI	311	Microbiology	(3-3)4
CH	335	Principles of Physical Chemistry	(3-3)4
		Two General Electives	(6-0)6
		Total hours	(15-9)18

Second Semester

BI	306	Biochemistry	(3-3)4
BI	330	Ecology	(3-3)4
CH	336	Principles of Physical Chemistry	(3-3)4
		General Elective	(3-0)3
		Technical Elective* or General Elective	2 or 3
		Total credit hours	17 or 18

*BI 370 (Genetics), BI 360 (Electron Microscopy), or MA 361 (Digital Computer Programming) recommended.

SENIOR YEAR

First Semester

BI	411	Research in Biology or Biology Elective	4
BI	451	Seminar in Biology	(1½-0)1
RS	441	Radioisotope Techniques	(3-3)4
		General Elective	(3-0)3
		Technical Elective	4
		Total credit hours	16

Second Semester

BI	412	Research in Biology or Biology Elective	4
BI	452	Seminar in Biology	(1½-0)1
BI	462	Radiation Biology	(3-0)3
		General Elective	(3-0)3
		Technical Elective	4
		Total credit hours	15

Not more than a total of six credits of junior or senior AS subjects may be substituted for technical or general electives.

The major objective of the curriculum in Business Administration is to provide an undergraduate professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The common aspects of the curriculum offer an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis is not technical but administrative. A common core of business and economic subjects — accounting, economics, finance, business law, marketing, production, statistics — is required of all students. An extensive selection of courses in languages and literature, the humanities and mathematics, broadens each student's intellectual capacity.

After a common freshman year each student is required to select a major track of study. These are: accounting, economics, and management. The management area is further subdivided into financial management, marketing management, and production management.

Freedom is provided in elective course selection but not to the degree that overspecialization is possible at this undergraduate level. The goal of the program is broad professional competence with a modest degree of specialization in one area.

FRESHMAN YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	191	Physical Science I	(3-0)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	142	Accounting II	(3-0)3
BA	192	Physical Science II	(3-0)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
		Total hours	(15-0)15

All nonveteran male students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given.

ELECTIVE COURSE GUIDELINES FOR ALL BA OPTIONS

Behavioral Science: The student may select any SS courses in Psychology and Sociology.

Humanities: Where a humanities elective is indicated a student may select any course bearing an EC, LL, or SS prefix not required in his curriculum. If the student is in the advanced Air Force R.O.T.C. program he will substitute AS 301, 302, 401, and 402, for the humanities electives normally taken in the junior and senior years.

Languages and Literature: In the sophomore year each student must elect two courses given with an LL prefix. If a foreign language offering is chosen, the student will have to have two years for credit. He may use the humanities electives provided for in his junior year for this purpose.

Management: The student, with the advice and consent of his Faculty Advisor, will select an area of concentration (finance, marketing, or production), and will take a minimum of four courses in that area. Where indicated, he may select additional management courses in his concentration area or in the other management disciplines. Overspecialization is not recommended at the undergraduate level.

ACCOUNTING OPTION
SOPHOMORE YEAR

First Semester

BA	241	Accounting III	(3-0)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		LL Elective	3
		Total credit hours	15

Second Semester

BA	242	Accounting IV	(3-0)3
EC	212	Economic Statistics II	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	(3-0)3
		LL Elective	3
		Total credit hours	15

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	341	Accounting V	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Principles	(3-0)3
BA	481	Insurance	(3-0)3
		Humanities Elective	3
		Total credit hours	18

Second Semester

BA	331	Business Finance	(3-0)3
BA	342	Accounting VI	(3-0)3
BA	344	Cost Accounting	(3-0)3
BA	363	Advanced Business Law	(3-0)3
		Humanities Elective	3
		Management Elective	3
		Total credit hours	18

SENIOR YEAR

First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	441	Auditing	(3-0)3
BA	444	Advanced Cost Accounting	(3-0)3
BA	451	Personnel Management	(3-0)3
		Management Elective	3
		Humanities Elective	3
		Total credit hours	18

Second Semester

BA	445	Tax Accounting	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Humanities Elective	3
		Management Elective	6
		Total credit hours	18

ECONOMICS OPTION
SOPHOMORE YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
SS	305	Sociology	(3-0)3
		Total hours	(15-0)15

Second Semester

EC	212	Economics Statistics II	(3-0)3
EC	304	Macroeconomic Theory	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
SS	301	Government of the United States	(3-0)3
SS	303	Psychology	(3-0)3
		Total hours	(15-0)15

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Principles	(3-0)3
EC	301	Economic Development	(3-0)3
EC	407	Econometrics	(3-0)3
		LL Elective	3
		Total credit hours	18

Second Semester

BA	331	Business Finance	(3-0)3
BA	346	Managerial Accounting	(3-0)3
EC	302	Labor Economics	(3-0)3
EC	404	Comparative Economic Systems	(3-0)3
		LL Elective	(3-0)3
		Humanities Elective	3
		Total credit hours	18

SENIOR YEAR

First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	451	Personnel Management	(3-0)3
BA	481	Insurance	(3-0)3
EC	402	Government and Business	(3-0)3
		Economics Elective	3
		Humanities Elective	3
		Total credit hours	18

Second Semester

BA	492	Physical Distribution Management	(3-0)3
EC	408	History of Economic Thought	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Economics Electives	6
		Humanities Elective	3
		Total credit hours	18

Economics Electives: EC 403, 409, 410, 411, 500.

MANAGEMENT OPTION
SOPHOMORE YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Behavioral Science Elective	3
		LL Elective	3
		Total credit hours	15

Second Semester

EC	212	Economic Statistics II	(3-0)3
EC	301	Economic Development	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	3
		LL Elective	3
		Total credit hours	15

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Principles	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
		Management Elective	3
		Humanities Elective	3
		Total credit hours	18

Second Semester

BA	331	Business Finance	(3-0)3
BA	346	Managerial Accounting*	(3-0)3
BA	372	Production Management	(3-0)3
		Humanities Elective	3
		Management Electives	6
		Total credit hours	18

*Production majors must take BA 344, Cost Accounting

SENIOR YEAR

First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	451	Personnel Management	(3-0)3
EC	402	Government and Business	(3-0)3
		Management Electives*	6
		Humanities Elective	3
		Total credit hours	18

*Production majors must take BA 444 — Advanced Cost Accounting

Second Semester

BA	452	Industrial Relations	(3-0)3
BA	492	Physical Distribution Management	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Management Electives	6
		Humanities Elective	3
		Total credit hours	18

Chemical Engineering is the only engineering discipline based on the science of chemistry, although it is broadly rooted in the other scientific disciplines as well. It combines elements of most of the other engineering disciplines and applies chemistry and engineering to industrial problems through the concepts of unit operations and unit processes.

The chemical process industries have provided a strong and continued growth with an ever-increasing demand for chemical engineering graduates. Current shortages of chemical engineerings are expected to persist for many years to come, leading to substantial increases both in opportunities and in financial rewards. The stability and dynamic growth of the chemical and allied industries opens up unparalleled challenges and growth prospects to the chemical engineer. The broad chemical and engineering training provided in this curriculum offers the graduate opportunities to enter Research and Development, Production, Sales, Marketing and General Management. It also gives him the tools to develop a career both stimulating and satisfying.

The student obtains a strong scientific background in the first two years, followed by two years of training in the discipline and related subjects. The curriculum provides maximum flexibility and allows for individual and original research if the student wishes. By taking several extra courses, it is possible to obtain a degree in Paper Engineering as well as Chemical Engineering. Considerable emphasis is placed on oral and written expression so necessary in the business world. Plant trips provide the essential link between theory and practice. Summer experience in the chemical industry is fostered. The student can enter either industry or graduate school upon graduation.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry I	(3-3)4
CN	203	Introduction to Chemical Engineering	(2-0)2
MA	203	Calculus III	(3-0)3
MA	360	Digital Computer Programming	(2-0)2
ME	215	Analytic Mechanics I	(3-0)3
		General Elective*	(3-0)3
		Total hours	(16-3)17

*Recommended General Elective: EC 201 Economics I (3-0)3

Second Semester

CH	224	Introductory Organic Chemistry II	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-0)2
CN	208	Chemical Engineering Laboratory I	(0-3)1
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Total hours	(14-6)16

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
CN	303	Transfer Operations I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
CN	315	Chemical Engineering Laboratory II	(0-3)1
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(15-6)17

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Transfer Operations II	(3-0)3
CN	316	Chemical Engineering Laboratory III	(0-3)1
EE	348	Basic Electrical Engineering Concepts	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(15-6)17

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	405	Transport Phenomena	(3-0)3
CN	416	Profession Orientation	(1-0)1
		General Elective*	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(16-0)16

*ROTC students may substitute AS 401

Second Semester

CN	408	Material Science	(3-0)3
CN	410	Process Analysis and Plant Design	(3-0)3
CN	414	Process Dynamics and Control	(3-0)3
		General Elective*	(3-0)3
		General or Technical Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 402

A total of 21 credit hours of General Electives and 9 credit hours of Technical Electives or 18 credits of General Electives and 12 hours of Technical Electives are required.

At least 3 hours of Technical Electives must be chosen from the following list:

CN	312	Chemical Engineering Thermodynamics II	(3-0)3
CN	407	Engineering Analysis of Chemical Processes	(3-0)3
CN	506	Colloid Chemistry for Chemical Engineers	(3-0)3

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

SOPHOMORE YEAR

First Semester

CH	207	Inorganic Chemistry	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
PH	201	Physics	(4-2)4
		Total hours	(15-9)17

Second Semester

CH	210	Analytical Chemistry I	(3-4)4
CH	222	Organic Chemistry	(3-4)4
CH	232	Physical Chemistry	(3-3)4
MA	204	Calculus IV	(3-0)3
		Total hours	(12-11)15

JUNIOR YEAR

First Semester

CH	311	Analytical Chemistry II	(2-4)3
CH	333	Physical Chemistry	(3-3)4
LL	261	Elementary Technical German	(3-0)3
		Two General Electives	(6-0)6
		Total hours	(14-7)16

Second Semester

CH	442	Advanced Inorganic Chemistry I	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		Chemistry Elective	3 or 4
		Two General Electives	(6-0)6
		Total credit hours	15 or 16

SENIOR YEAR

First Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

Second Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

The Technical Electives in the Junior and Senior years must include chemistry subjects which will provide a minimum of 60 contact hours of laboratory instruction. Recommended laboratory electives include CH 321, CH 342, CH 403 and 404, CH 407 and 408 and CH 481 and 482. If Undergraduate Thesis is elected, both semesters must be taken, and one additional laboratory subject must also be taken to provide an approved program.

The General Electives in the Junior and Senior years must include a minimum of 18 credits in Humanities and Social Studies not including elementary foreign language, composition, or communication subjects.

A student electing Air Force ROTC in the Junior and Senior years may substitute a maximum of six credits of required General or Technical Electives by AS subjects. It is recommended that this substitution be made in the Senior year.

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and processing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes; and the adaptation of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's actvities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are Civil Engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

SOPHOMORE YEAR

First Semester

CE	201	Surveying I	(3-4)4
EC	201	Economics I	(3-0)3
MA	203	Calculus III	(3-0)3
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(16-6)17

Second Semester

CE	202	Surveying II	(3-4)4
EC	202	Economics II	(3-0)3
MA	204	Calculus IV	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
PH	202	Physics	(4-2)4
		Total hours	(16-6)17

JUNIOR YEAR

First Semester

CE	341	Transportation	(3-3)4
EE	211	Fundamentals of Electricity	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	309	Dynamics I	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-3)18

Second Semester

CE	312	Structures I	(3-0)3
CE	322	Hydraulics	(4-0)4
EE	212	Introductory Electronics	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
MA	362	Numerical Analysis	(3-0)3
ME	304	Materials Laboratory	(0-3)1
		General Elective	(3-0)3
		Total hours	(16-6)18

SENIOR YEAR

First Semester

CE	411	Structures II	(3-3)4
CE	413	Concrete	(3-3)4
CE	421	Hydrology	(3-3)4
CE	431	Soil Mechanics I	(3-0)3
		General or Technical Elective*	(3-0)3
		Total hours	(15-9)18

*ROTC students may substitute AS 401

Second Semester

CE	412	Structures III	(3-3)4
CE	432	Soil Mechanics II	(3-3)4
EC	414	Engineering Economy	(3-0)3
LL	210	Technical and Scientific Communication	(3-0)3
		General or Technical Elective*	(3-0)3
		Total hours	(15-6)17

*ROTC students may substitute AS 402

CIVIL ENGINEERING TECHNOLOGY

The following curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering Technology is available only to employees of the Commonwealth of Massachusetts and its political subdivisions as an In-Service Training Program. For regulations concerning this program and for subjects required prior to the following curriculum, consult the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

This curriculum is accredited by the Engineers' Council for Professional Development.

JUNIOR YEAR

Second Semester

CE	961	Advanced Surveying	(2-1)2
CE	971	Structures	(2-1)2
DP	930	Scientific Computer Programming — FORTRAN	(2-1)2
LL	962	American Literature	(3-0)3
PH	942	Physics	(3-2)4
		General Elective	(3-0)3
		Total hours	(15-5)16

SENIOR YEAR

First Semester

CE	982	Hydrology	(3-3)4
CE	991	Concrete Analysis and Design	(3-3)4
CE	995	Engineering Laboratory	(0-3)1
EE	975	Basic Electricity	(3-3)4
		General Elective	(3-0)3
		Total hours	(12-12)16

Second Semester

CE	981	Structural Analysis and Design	(3-3)4
CE	992	Soil Mechanics	(3-3)4
CE	994	Engineering Problems	(2-1)2
EC	414	Engineering Economy	(3-0)3
EE	978	Basic Electronics	(3-0)3
		Total hours	(14-7)16

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

This curriculum is accredited by the Engineers' Council for Professional Development.

Many of the courses required in the Electrical Engineering curriculum are heavily dependent upon rather sophisticated mathematical techniques. It is therefore recommended that a freshman seeking admission into the sophomore year of Electrical Engineering should have received grades of not less than C— in all freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory I	(4-0)4
EE	207	Basic Electrical Engineering Laboratory I	(1-3)2
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory II	(4-0)4
EE	208	Basic Electrical Engineering Laboratory II	(1-3)2
MA	204	Calculus IV	(3-0)3
ME	212	Mechanics and Properties of Matter	(4-0)4
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EE	311	Electronics Laboratory I	(1-3)2
EE	315	Signal and System Analysis	(4-0)4
		or	
EE	318	Digital Computation in Electrical Engineering	(3-3)4
EE	319	Electronics I	(4-0)4
MA	313	Engineering Mathematics	(4-0)4
		General Elective	(3-0)3
		Total credit hours	17

Second Semester

EE	306	Electromagnetic Theory	(4-0)4
EE	312	Electronics Laboratory II	(1-3)2
EE	318	Digital Computation in Electrical Engineering	(3-3)4
		or	
EE	315	Signal and System Analysis	(4-0)4
EE	320	Electronics II	(4-0)4
		General Elective	(3-0)3
		Total credit hours	17

SENIOR YEAR

First Semester

EE	413	Linear Feedback Systems	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		General Elective	(3-0)3
		EE Technical Elective	3
		General or Technical Elective*	3
		Total credit hours	15

*ROTC students may substitute AS 401

Second Semester

EE	454	Electromechanics	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		General or Technical Elective	3
		General or Technical Elective*	3
		Total credit hours	15

*ROTC students may substitute AS 402

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide a student with a sound foundation in the pure sciences and mathematics, in the humanities, and in the social sciences. In addition, the core subjects of management — accounting, finance, marketing and production — are required. All students also take a selection of engineering and management courses to prepare them to handle the tasks they will have in industry after graduation. Some specialization is provided in the junior and senior years under guidance of a Faculty Advisor.

SOPHOMORE YEAR

First Semester

BA	143	Accounting Management I	(3-0)3
CH	001	Chemical Principles	(4-0)3
CH	003	Chemical Principles Laboratory	(0-2)1
MA	203	Calculus III	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
PH	201	Physics	(4-2)4
		Total hours	(15-7)16

Second Semester

BA	144	Accounting Management II	(3-0)3
CH	002	Chemical Principles	(4-0)3
CH	004	Chemical Principles Laboratory	(0-2)1
EC	211	Economic Statistics I	(3-0)3
LL	210	Technical & Scientific Communication	(3-0)3
MA	204	Calculus IV	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
		Total hours	(17-0)17

Second Semester

BA	403	Electronic Data Processing	(3-0)3
IM	372	Production Problems	(3-0)3
IM	483	Statistical Quality Control	(3-0)3
ME	372	Strength of Materials	(3-0)3
		Humanities Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

BA	404	Computer Applications to Management	(3-0)3
BA	451	Personnel Management	(3-0)3
MA	381	Operations Research	(3-0)3
EE	351	Industrial Electronics	(3-0)3
		Humanities Elective	3
		Management Elective*	3
		Total credit hours	18

*ROTC students may substitute AS 401

Second Semester

EC	412	Managerial Economics	(3-0)3
ME	344	Heat and Power	(3-0)3
		Operations Research	3
		Management Elective*	3
		Humanities Elective	3
		Total credit hours	15

*ROTC students may substitute AS 402.

MATHEMATICS

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics — algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

The approaches to these objectives are also twofold, viz., by way of course work and supervised project activity. In order to achieve breadth, each of the major areas mentioned above is represented by at least one required three-hour subject. A deeper study of one or more areas is provided by the student's elective program, subject to the approval of his departmental advisor.

The purpose of the project work is to enable the student to "read, write, and speak" mathematics via the reading of simple journal articles, the preparation of short papers, and oral presentations. This aspect of the program is regarded as at least as important as the formal course work. Participation in a working seminar is required of all mathematics majors during the senior year.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields of teaching and industry.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MA	221	Linear Algebra	(3-0)3
PH	201	Physics	(4-2)4
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

MA	204	Calculus IV	(3-0)3
MA	222	Linear Algebra	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-0)17

JUNIOR YEAR

First Semester

MA	305	Introduction to Real Analysis	(3-0)3
MA	321	Modern Algebra	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

MA	306	Introduction to Real Analysis	(3-0)3
MA	334	Projective Geometry	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

**To be selected from an approved department list.

SENIOR YEAR

First Semester

MA	411	Complex Variables I	(3-0)3
MA	431	Topology I	(3-0)3
MA	497	Foundations of Mathematics	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 401.

Second Semester

MA	498	Mathematics Seminar	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 402.
**To be selected from an approved departmental list.

MECHANICAL ENGINEERING

Mechanical Engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and automatic controls (electricity, electronics, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, technical electives are provided in the senior year. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	206	Mechanical Engineering Laboratory I	(0-3)1
ME	220	Mechanics of Materials I	(3-0)3
ME	242	Thermodynamics	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-3)18

JUNIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
MA	301	Advanced Calculus for Applications	(3-0)3
ME	307	Mechanical Engineering Laboratory II	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	382	Fluid Mechanics I	(3-0)3
ME	395	Materials Science	(3-0)3
		Total hours	(15-3)16

Second Semester

EC	202	Economics II	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
ME	308	Mechanical Engineering Laboratory III	(0-3)1
ME	320	Machine Design I	(2-3)3
ME	343	Heat Transfer	(3-0)3
ME	354	Dynamic Systems	(3-0)3
		Total hours	(14-6)16

SENIOR YEAR

First Semester

ME	407	Mechanical Engineering Laboratory IV	(0-3)1
ME	413	Gas Dynamics	(3-0)3
ME	417	Dynamics II	(3-0)3
ME	453	Senior Project I	(0-3)1
ME	497	Automatic Control Systems	(3-0)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	17

*ROTC students may substitute AS 401.

APPROVED TECHNICAL ELECTIVES

EE	353	Electrical Controls and Power Circuits	(3-0)3
ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	473	Mechanics of Materials II	(3-0)3
ME	488	Environmental Conditioning	(3-0)3
ME	500	Series subjects open to undergraduate by petition	

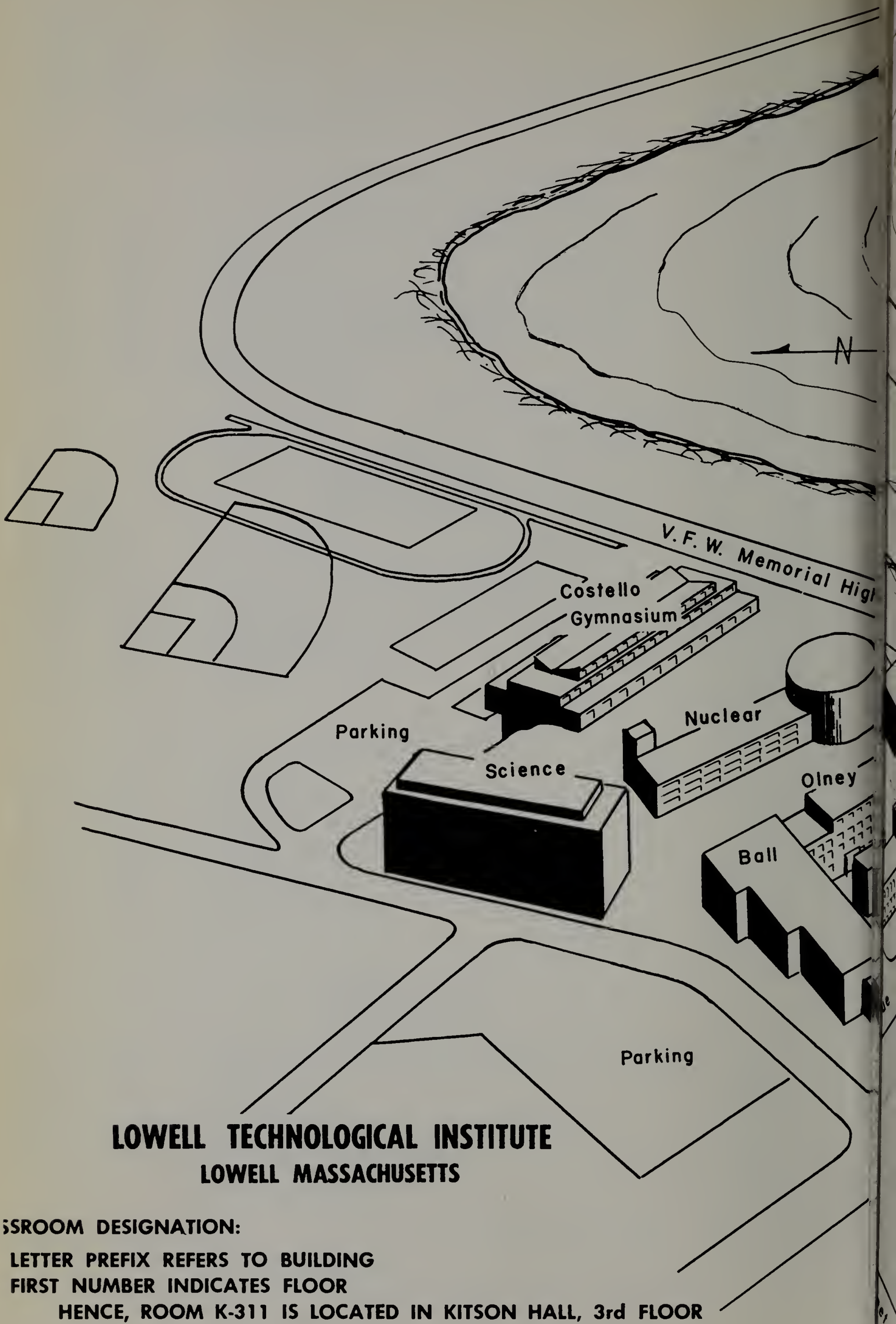
Second Semester

ME	454	Senior Project II	(0-6)2
		Technical Elective	3
		Technical Elective	3
		General Elective	3
		General or Technical Elective	3
		General or Technical Elective*	3
		Total credit hours	17

*ROTC students may substitute AS 402.

APPROVED TECHNICAL ELECTIVES

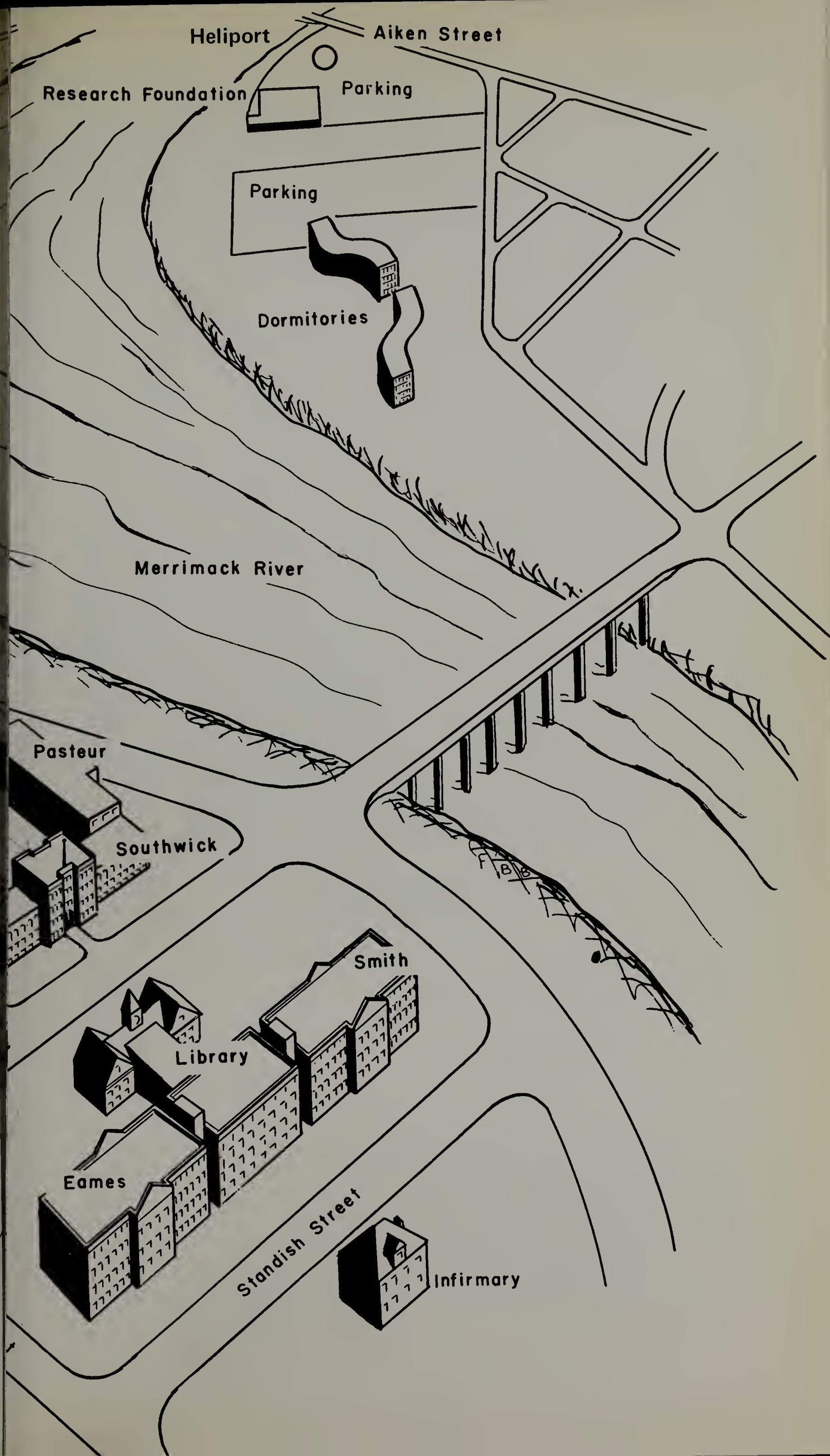
ME	428	Kinematic Mechanism Synthesis	(3-0)3
ME	452	Applications of Numerical Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	475	Physical Metallurgy	(3-0)3
ME	500	Series subjects open to undergraduates by petition	



LOWELL TECHNOLOGICAL INSTITUTE
LOWELL MASSACHUSETTS

SSROOM DESIGNATION:

LETTER PREFIX REFERS TO BUILDING
FIRST NUMBER INDICATES FLOOR
HENCE, ROOM K-311 IS LOCATED IN KITSON HALL, 3rd FLOOR


Heliport
Aiken Street
Research Foundation
Parking
Parking
Dormitories
Merrimack River
Pasteur
Southwick
Smith
Library
Eames
Standish Street
Infirmary

METEOROLOGY

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of the other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of tomorrow's weather for the general public to the analysis of the influence of weather and climate on particular operations in agriculture, engineering, industry and commerce, national defense and public health. Meteorologists are employed in these capacities by the agencies of the Environmental Science Services Administration, especially the Weather Bureau, by agencies of the Defense Department and by commercial aviation companies and private consulting firms. Meteorological research conducted by agencies of the U.S. Government, universities and private research companies is becoming increasingly important as a field of employment. Although graduate training is essential for advancement in this field, the U.S. Government and most private employers provide opportunities for individuals to acquire this training. The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MY	205	Elementary Meteorology	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	16

Second Semester

MA	204	Calculus IV	(3-0)3
MY	206	Elementary Meteorology	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
MY	301	Atmospheric Dynamics	(3-0)3
MY	308	Synoptic Meteorology	(2-3)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
MY	302	Atmospheric Dynamics	(3-0)3
MY	307	Tropical Meteorology	(3-0)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

MY	403	Physical Meteorology	(3-0)3
MY	415	Advanced Atmospheric Dynamics	(3-0)3
MY	421	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may substitute AS 401.

Second Semester

MY	413	Oceanography	(3-0)3
MY	416	Advanced Atmospheric Dynamics	(3-0)3
MY	422	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may substitute AS 402.

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

Six general electives are required and can be selected from the elective system with the exception of LL 261-262, LL 365-366 and EC 301 thru EC 414.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	242	Thermodynamics	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-4)16

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
MA	302	Advanced Calculus for Applications	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(13-7)16

SENIOR YEAR

First Semester

ME	382	Fluid Mechanics I	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
RS	401	Principles of Radiation Safety and Control*	(3-0)3
		General Elective	(3-0)3
		Total hours	(12-6)15

*ROTC students may substitute AS 401.

Second Semester

ME	443	Heat Transfer	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
		General Elective	(3-0)3
		Technical Elective*	2 or 3
		Total credit hours	14 or 15

*ROTC students may substitute AS 402.

APPROVED TECHNICAL ELECTIVES

EE	446	Digital Devices and Techniques	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3
NU	495	Special Nuclear Problems	(3-0)3

Paper Engineering is an engineering discipline, strongly based in Chemical Engineering but with major emphasis on the technical aspects of the Paper Industry. The Paper Engineer is thus able to enter not only the Chemical Process Industries but the Paper Industry as well.

The Paper Industry is the fifth largest industry in the United States. By virtue of satisfying basic human needs and its broad spectrum of products, it provides both dynamic growth and stability. The products of the Paper Industry and its sister industries are integral to every aspect of human life and endeavor.

Because of the increasing complexity of pulp and paper operations and of the converting industry, there is an intense and growing demand for well-trained engineers in all aspects of the business. The converting industry particularly involves not only paper but plastics, chemicals, metals and other materials as well. Engineers trained for this group of industries must not only have a fundamental scientific training but a broad background of practical problem solving as well.

The Paper Engineering Curriculum is basically Chemical Engineering with a minor in Paper Engineering. In fact, the two degrees may be obtained by taking four extra courses in Chemical Engineering. Emphasis is placed on an engineering analysis of the Paper Industry, its production methods, economics, fundamental properties of its raw materials and the Unit Operations involved in manufacturing. The graduates of Paper Engineering may go either directly into industry or may continue on to graduate studies. In the paper and allied industries they find themselves in positions in Research and Development, Producting, Sales, or Marketing, Sales Service and frequently in General Management.

Paper Engineers who maintain a 2.00 cumulative rating are eligible for scholarships with a $500 annual stipend.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry I	(3-3)4
CN	203	Introduction to Chemical Engineering	(2-0)2
MA	203	Calculus III	(3-0)3
MA	360	Digital Computer Programming	(2-0)2
ME	215	Analytic Mechanics I	(3-0)3
		General Elective**	(3-0)3
		Total hours	(16-3)17

**Recommended General Elective: EC 201 Economics I

Second Semester

CH	224	Introductory Organic Chemistry II	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-0)2
CN	208	Chemical Engineering Laboratory I	(0-3)1
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Total hours	(14-6)16

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
CN	303	Transfer Operations I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
CN	315	Chemical Engineering Laboratory II	(0-3)1
PA	301	Engineering Analysis of Pulp Systems	(3-0)3
PA	307	Physical Testing and Data Analysis	(2-3)3
		Total hours	(14-9)17

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Transfer Operations II	(3-0)3
CN	316	Chemical Engineering Laboratory III	(0-3)1
EE	348	Basic Electrical Engineering Concepts	(3-0)3
PA	302	Engineering Analysis of Paper Systems	(3-3)4
		General Elective	(3-0)3
		Total hours	(15-9)18

SENIOR YEAR

First Semester

CN	405	Transport Phenomena	(3-0)3
CN	416	Profession Orientation	(1-0)1
PA	403	Engineering Analysis of Converting	(3-0)3
PA	405	Paper Converting Laboratory I	(0-3)1
		Technical Elective	(2-0)2
		General Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

*ROTC students may substitute AS 401.

Second Semester

CN	414	Process Dynamics and Control	(3-0)3
PA	406	Pulp and Paper Systems Calculations	(2-0)2
PA	408	Paper Converting Laboratory II	(0-3)1
		General Elective*	(3-0)3
		General Elective	(3-0)3
		Technical Elective	2 or 3
		Total credit hours	14 or 15

*ROTC students may substitute AS 402.

A total of 18 credit hours of General Electives and 6 credit hours of Technical Electives are required. At least 4 credit hours of Technical Electives must be chosen from the following list:

CN	506	Colloid Chemistryf or Chemical Engineers	(3-0)3
PA	410	Analysis of Paper Formation Process	(2-0)2
PA	419	Special Senior Projects	Credits to be Arranged
PA	505	Physics of Paper	(3-0)3
PA	507	Fundamentals of Reprography	(2-0)2
PA	512	Advanced Fiber Processing	(3-0)3

Not over 6 credits in AS subjects may be substituted for General Electives.

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

SOPHOMORE YEAR

First Semester

PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	211	Physics	(3-0)3
PH	293	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(12-6)14

Second Semester

PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	212	Physics	(3-0)3
PH	294	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(12-6)14

JUNIOR YEAR

First Semester

PH	311	Intermediate Mechanics	(3-0)3
PH	335	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	393	Advanced Laboratory	(0-6)2
		General or Technical Elective	(3-0)3
		Total hours	(12-6)14

Second Semester

PH	312	Intermediate Mechanics	(3-0)3
PH	336	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	394	Advanced Laboratory	(0-6)2
		General or Technical Elective	(3-0)3
		Total hours	(12-6)14

SENIOR YEAR

First Semester

PH	423	Thermodynamics	(3-0)3
		General or Technical Elective	(3-0)3
		General or Technical Elective	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 401.

Second Semester

PH	424	Introduction to Statistical Mechanics	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 402.

TECHNICAL ELECTIVES

PH	441-442	Introduction to Relativity and Quantum Mechanics	(3-0) (3-0)6
PH	461-462	Nuclear Physics	(3-0) (3-0)6
PH	471-472	Solid State Physics	(3-0) (3-0)6
PH	495-496	Special Research Problems	(3-0) (3-0)6
PH	505-506	Mathematical Methods of Physics	(3-0) (3-0)6
PH	511-512	Classical Mechanics	(3-0) (3-0)6
MA	411	Complex Variables I	(3-0)3
MA	434	Matrix Algebra	(3-0)3
MA	484	Probabilities	(3-0)3
MA	542	Fourier Series and Boundary Value Problems	(3-0)3
MA	575	Operational Mathematics	(3-0)3

All physics majors must take no less than six and no more than ten General Electives. In addition to the approved technical electives, any course offered by the Institute, and which is approved by the Student Advisor may be taken as technical elective.

In addition, two must be in some foreign language usually French, German, or Russian.

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry, strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, and engineering and plastics technology to round out a well-balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the international Society of Plastics Engineers, an opportunity which affords every student member an early and rewarding professional association.

With additional elective courses in plastics and related departments, this curriculum prepares the student for either direct entrance into the plastics industry or for the MS program in plastics at LTI or other universities.

SOPHOMORE YEAR

First Semester

CH	211	Quantitative Analysis	(3-4)4
		or	
CH	205	Qualitative Analysis	(3-0)3
CH	223	Introductory Organic Chemistry I	(3-3)4
MA	203	Calculus III	(3-0)3
PH	201	Physics III	(4-2)4
PL	201	Introduction to Polymeric Materials	(2-0)2
		Total hours	(15-5)16
			or (15-9)17

Second Semester

CH	205	Qualitative Analysis	(3-0)3
		or	
CH	211	Quantitative Analysis	(3-4)4
CH	224	Introductory Organic Chemistry II	(3-3)4
EE	353	Electrical Controls and Power Circuits	(3-0)3
LL	210	Technical and Scientific Communication	(3-0)3
MA	383	Statistical Methods	(3-0)3
PL	202	Introduction to Polymeric Materials	(2-0)2
		Total hours	(17-3)18
			or (17-7)19

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
ME	373	Plastics Mold and Die Design	(2-2)3
PL	301	Plastics Technology I	(2-2)3
		Total hours	(14-10)18

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
EC	202	Economics II	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
ME	376	Plastics Mold Design and Construction	(0-3)1
ME	395	Materials Science	(3-0)3
PL	302	Plastics Technology II	(2-2)3
		Total hours	(14-8)17

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology III	(2-2)3
PL	403	Physical Properties of Polymers	(2-2)3
PL	411	Plastics Seminar	(1-0)1
		Elective	3
		Total credit hours	16

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
PL	402	Plastics Technology IV	(2-2)3
PL	404	Physical Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
		Two Electives	6
		Total credit hours	17

Suggested Electives

CH	423 and 424	Advanced Organic Chemistry	(3-0) (3-0)6
IM	483	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Technical German	(3-0) (3-0)6
MA	204	Calculus IV	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	242	Thermodynamics	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
ME	413	Gas Dynamics	(3-0)3
PL	406	Polymer Structure	(3-0)3
PL	407	Plastics Industry Organization	(3-0)3
PL	409 and 410	Senior Research in Plastics	(1-6) (1-6)6

A student electing Air Force ROTC in the Junior and Senior years may :titute a maximum of six credits of General or Technical Electives by AS :cts. It is recommended that this substitution be made in the Senior year.

RADIOLOGICAL HEALTH PHYSICS

The Radiological Health Physics Program offered by the Department of Radiological Sciences is designed to provide needed professional personnel to help advance the safe utilization of nuclear energy and radiation. It is conducted through the cooperation of other departments and provides the best education and experience within the practical limitations imposed by time and resources to carefully selected and highly motivated students. The program is supported by the Bureau of Radiological Health, Environmental Control Administration, Department of Health, Education and Welfare. The program includes specialized training and education during the summer months.

The academic program is broad based in the basic sciences so that students will be able to recognize and appreciate the many complex and interrelating factors in the solution of problems facing the nuclear industry.

Students will benefit from cooperative summer training programs utilizing the radiation facilities and staff of the LTI Nuclear Center, government laboratories, industries, and major hospitals. This training and education in the nuclear sciences and radiological health gives experience with equipment and methods characteristic of current techniques and philosophy of professional practice in the radiation protection field, The summer program enables students to better select a professional position after graduation and better equips them for the pursuit of advanced degrees and research in the field.

Summer

RS	100	Basic Radiological Health Physics	8 weeks

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-5)17

Second Semester

BI	202	Principles of Biology	(3-3)4
EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-5)17

Summer

RS	200	Reactor and Accelerator Radiation and Hazards Evaluation	3 weeks lecture 1 week applied work experience
RS	210	Medical Radiation Physics and X-Ray Protection	3 weeks lecture 1 week applied work experience

JUNIOR YEAR

First Semester

LL	209	Technical and Scientific Communication	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-4)17

Second Semester

BI	462	Radiation Biology	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-4)17

Summer

RS	300	Applied Radiological Health Physics	10 weeks work experience

SENIOR YEAR

First Semester

CH	481	Radiochemistry	(2-3)3
RS	411	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	431	Seminar in Radiological Sciences	(2-0)1
RS	451	Introduction to Electronic Product Radiation	(3-0)3
		General Elective*	(3-0)3
		Total credit hours	12, 13 or 14

*ROTC students may substitute AS 401.

Second Semester

CH	482	Radiochemistry	(2-3)3
RS	412	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	432	Seminar in Radiological Sciences	(2-0)1
RS	452	Electronic Product Radiation Laboratory	(1-4)3
		General Elective*	(3-0)3
		Total credit hours	12, 13 or 14

*ROTC students may substitute AS 402.

Approved Technical Electives

MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
RS	401	Principles of Radiation Safety and Control	(3-0)3
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3
RS	501	Radiation Physics and Shielding Design	(3-0)3
RS	503	Introduction to Radiation Chemistry	(3-0)3

TEXTILE ENGINEERING

The object of this curriculum in Textile Engineering is to provide the student with a firm understanding of scientific principles and their application to the textile industry and its related branches.

During the first two years the student is thoroughly instructed in basic mathematics, physics, and chemistry. This fundamental work is followed by more specialized training in the field of Textiles and related areas of Mechanical Engineering.

A wide range of laboratory work is included in the curriculum in order to demonstrate both the use of the experimental method in the solution of engineering problems and to give a practical understanding of textile procedure.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
TE	211	Chemistry and Physics of Textile Fibers	(3-1)3
TE	263	Textile Systems I	(3-1)3
		Total hours	(16-4)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	383	Statistical Methods	(3-0)3
ME	208	Introduction to Kinematics	(3-0)3
TE	264	Textile Systems II	(3-3)4
		General Elective	(3-0)3
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	215	Analytic Mechanics I	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
TE	331	Textile Systems III	(3-1)3
		General Elective	(3-0)3
		Total hours	(17-4)18

Second Semester

EC	202	Economics II	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	216	Analytic Mechanics II	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
TE	332	Textile Systems IV	(3-3)4
		General Elective	(3-0)3
		Total hours	(17-3)18

SENIOR YEAR

First Semester

ME	395	Materials Science	(3-0)3
ME	453	Senior Project I	(0-3)1
ME	488	Environmental Conditioning	(3-0)3
TE	433	Technology of Knitting	(2-2)3
TE	459	Textile Systems V	(3-0)3
TE	482	Application of Scientific Methods to Textile Processes*	(3-0)3
TE	483	Engineering Design of Textile Structures I	(3-0)3
		Total hours	(17-5)19

*ROTC students may substitute AS 401

Second Semester

ME	454	Senior Project II	(0-6)2
TE	460	Textile Systems VI	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
TE	484	Engineering Design of Structures II	(3-0)3
		Elective*	3
		Total credit hours	16

*ROTC students may substitute AS 402

ELECTIVES

EC	414	Engineering Economy	(3-0)3
ME	421	Machine Design	(2-3)3
TE	434	Advanced Knitting	(2-2)3

Other ME or TE subjects with the approval of the Department Head.

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospace Studies	MA	Mathematics
BA	Business Administration	ME	Mechanical Engineering
BI	Biological Sciences	MY	Meteorology
CE	Civil Engineering	NU	Nuclear Engineering
CH	Chemistry	PA	Paper
CN	Chemical Engineering	PH	Physics
DP	Data Processing	PL	Plastics
EC	Economics	RS	Radiological Sciences
EE	Electrical Engineering	SS	Social Sciences
IM	Industrial Management	TE	Textiles
LL	Languages and Literature		

SUBJECT NUMBERS

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are normally for graduate students but may be taken by undergraduates in certain cases with special permission.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

PREREQUISITES

Prerequisites and restrictions are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

CLASS AND CREDIT HOURS

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AEROSPACE STUDIES

AS 101-102 World Military Systems I (1-1) (1-1)2

An introductory course exploring the causes of world conflict and the role of the United States military forces as an instrument of national power. Particular emphasis is placed upon the doctrine, mission and organization of the US Air Force and the responsibilities of an Air Force officer. The course continues with an in-depth study of US strategic offenses and defensive forces and ends with an examination of the specific functions of US General Purpose and Aerospace Support Forces.

AS 201-202 World Military Systems II (1-1) (1-1)2

A brief study of defense policies as related to the strategies of the United States, the Soviet Union and China. The course continues with the study of defense organization, the role of the military in United States national policies and concludes with an examination of the factors involved in defense decision making.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the nature of war; development of airpower in the United States; mission and organization of the Defense Department; Air Force concepts, doctrine and employment; astronautics and space operations; and the future development of aerospace power, including US space programs, vehicles, systems, and problems in space exploration. The above areas are studied through the media of briefings, discussions, debates and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership and introductory management principles. Classroom and organizational situations allow application of leadership and management skills, stress professional and personal responsibility and improve communicative skills through classroom discussions and student presentations.

BUSINESS ADMINISTRATION

BA 141-142 Account I and II (3-0) (3-0)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 143-144 Accounting Management I and II (3-0) (3-0)6
[I.M. Students Only]

These courses are designed to give the industrial management student an understanding of accounting concepts and techniques. Special emphasis on the role of cost accounting in the manufacturing process.

BA 191 Physical Science I (3-0)3

An introduction to the topics of physics and astronomy including: kinematics, dynamics, energy, heat, atoms and molecules, wave motion, electricity, magnetism and the solar system.

BA 192 Physical Science II (3-0)3
[BA 191]

A survey of topics in modern physics, chemistry, and geology including: relativity, waves and particles, Bohr theory of the atom, periodic table, chemical bond, ions and solutions, chemical reactions, earth materials, and study of the atmosphere.

BA 241-242 Accounting III and IV (3-0) 3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3
[EC 202]

An analysis of the marketing of goods and services to business and final consumers. Decision areas involving product planning, distribution, promotion, and pricing are based on a framework of consumer behavior, governmental constraints, and a study of the business institutions involved.

BA 324 Industrial Marketing (3-0)3
[BA 321]

Special problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing strategy. Cases will be used.

BA 325 Advertising (3-0)3
[BA 321]

Commencing on a foundation of the historical evolution of advertising and the economic and social role of promotion, this course takes an in-depth look at advertisers, advertising agencies, and media as well as advertising creation and evaluation.

BA 326 Marketing Research (3-0)3
[BA 321, EC 212]

The process of planning, executing, and evaluating marketing research which is the information-gathering function of marketing management. Students work on individual research projects in the course.

BA 331 Business Finance (3-0)3
[BA 142, EC 202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 Money and Banking (3-0)3
[EC 202]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutions, and international monetary systems.

BA 334 Investment Management (3-0)3
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 Accounting V and VI (3-0) (3-0)6
[BA 242]

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(3-0)3**
[BA 142]
(For Accounting Majors)

Job lot, process, and standard cost systems, including joint and byproduct problems, and the managerial uses of cost data.

BA 346 **Managerial Accounting** **(3-0)3**
[BA 142]
(For Non-accounting Majors)

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 **Business Law** **(3-0)3**

Principles of commercial law encompassing a study of contracts, agency, employment, commercial paper and sales including the Uniform Commercial Code.

BA 363 **Advanced Business Law** **(3-0)3**
[BA 362]

The analysis of the legal principles underlying real and personal property, corporations, partnerships, trusts and estates.

BA 371 **Production Principles** **(3-0)3**

Principles of manufacturing organization and productive processes with emphasis placed upon the functions of production systems; operational planning and control; plant layout; materials handling; inventory and quality control.

BA 372 **Production Management** **(3-0)3**
[BA 371]

A case course in the application of the principles covered in BA 371. The cases are representative of a wide range of products and industries. Small, medium and large manufacturing enterprises are studied; consideration is given to intermittent, continuous, and job lot systems of production.

BA 402 **International Business** **(3-0)3**
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's computer installation.

BA 404 Computer Applications to Management (3-0)3
[BA 403]

An investigation of the applications of electronic computers in the management of business enterprises. Attention is given to problems of management under conditions of uncertainty, inventory and production control, queuing theory, linear and non-linear programming.

BA 421 Procurement (3-0)3
[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 423 Marketing Management (3-0)3
[BA 321]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 Sales Management (3-0)3
[BA 321]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

BA 431 Financial Management (3-0)3
[BA 242, BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 441 Auditing (3-0)3
[BA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 444 Advanced Cost Accounting (3-0)3
[BA 344]

Estimated cost systems, budgeting control with standard costs, and cost and profit analysis for decision-making purposes.

BA 445 Tax Accounting (3-0)3
[BA 242]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 448 Seminar in Accounting (3-0)3
(For Accounting Seniors Only)

Readings in accounting history and thought, economics as it relates to accounting, contemporary accounting problems, controversies in current accounting practice comprise the foundation of the seminar. Students select a contemporary accounting problem for research and preparation of a paper which is defended before members of the class.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 Industrial Relations (3-0)3
[BA 451]

Human interaction and group behavior in organized industrial settings, interpersonal intergroup conflict, motivation, and leadership.

BA 481 Insurance (3-0)3

Theory of risk, physical and moral hazards, types of insurance carriers, and basic features of each of the principal kinds of insurance.

BA 492 Physical Distribution Management (3-0)3

Emphasis on the analytical needs involved in the management of the functions that comprise physical distribution: warehousing, inventory control, material handling, and industrial

packaging. Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies in the United States.

BA 500 Research Seminar 3
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

BIOLOGICAL SCIENCES

BI 201 Principles of Biology (3-3)4
[CH 002, CH 004]

Part one of a basic course which includes an introduction to cell structure, cellular metabolism, molecular genetics, protein synthesis, bacteria and viruses, and systems of the human body.

BI 202 Principles of Biology (3-3)4
[BI 201]

Part two of a basic course dealing with the structure, function, and diversity of living organisms including a brief survey of the animal and plant kingdoms, photosynthesis, developmental biology, population genetics, ecology and evolution.

BI 301 Physiology (3-3)4
[BI 202]

Structural, chemical and physical aspects of important processes in mammals. Mechanisms operative at the molecular, cellular, and organismic levels related to (1) intake, transport, metabolism and excretion of gases and nutrients, (2) immune protection, (3) muscle contraction and (4) integrative activity of the nervous and endocrine systems.

BI 306 Biochemistry (3-3)4
[CH 222 or 224; CH 232 or 336 concurrently]

Fundamental concepts in biochemistry including protein structure and biosynthesis; enzyme structures and mechanisms; nucleic acids and genetic development; metabolism; photosynthesis; cellular structure; functions and structure of carbohydrates, hormones, lipids, and hemins; chemical functions of organs.

BI 311 **Microbiology** **(3-3)4**
[BI 202]

A study of the morphology and the chemical and physical activities of representative bacteria, yeasts, molds, viruses and animal parasites as related to man. The laboratory covers basic qualitative and quantitative techniques of microbiology with an introduction to selected immunochemical methods.

BI 330 **Ecology** **(3-3)4**
[BI 202]

A course dealing with factors responsible for the relationships of living organisms to each other and to their natural environment. The nature and dynamics of the biotic community.

BI 360 **Electron Microscopy** **(2-3)3**
[BI 202]

An introduction to the theory and operation of the electron microscope. Preparation of biological specimens for EM viewing and photography will be stressed. Applications in biology will be discussed.

BI 370 **Genetics** **(3-0)3**
[BI 202]

The laws of biological inheritance. The molecular basis of heredity is stressed. Replication of DNA, genetic codes and fine structures of chromosomes are considered.

BI 410 **Industrial Biology** **(3-0)3**

Fundamental aspects of physiology and microbiology followed by a consideration of the effects of chemical and microbial pollutants of air and water on biological systems. Pollution control, sanitation, food preservation as related to industrial management. Not open to biology majors.

BI 411-412 **Research in Biology** **(0-12) (0-12)8**

An individual, directed research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration, is required.

BI 451-452 **Seminar in Biology** **(1½-0) (1½-0)2**

Seminar discussion of selected topics of current research interest. Offered each semester by a different member in his

special discipline. Student participation in the form of discussion and presentation of papers. For senior biology majors.

BI 462 **Radiation Biology** **(3-0)3**
[BI 202, RS 441]

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and late effects in whole animals and the modification of radiation exposure by physical, chemical and biological factors.

BI 481 **Immunology** **(3-3)4**
[BI 311]

Lectures dealing with the theories of infection and immunity are correlated with a laboratory study of antigens, antibodies, and antiserums emphasizing immunochemical techniques.

BI 482 **Immunoparasitology** **(3-3)4**
[BI 481]

The principles of animal parasitism are considered. The immunological aspects of the host-parasite relationship are stressed.

CIVIL ENGINEERING

CE 201 **Surveying I** **(3-4)4**
[MA 103; ME 104]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 202 **Surveying II** **(3-4)4**
[CE 201]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering.

CE 312 **Structures I** **(3-0)3**
[ME 220]

An introduction to the principles of structural analysis with applications to typical Civil Engineering structures. Emphasis will be on the analyses of statically determinate planar structures.

CE 322 **Hydraulics** **(4-0)4**
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits. An introduction to the basic concepts of hydrodynamics and hydraulic similitude.

CE 341 **Transportation** **(3-3)4**
[CE 202]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic, materials of construction and the basic concepts of transportation economics, finance and administration.

CE 411 **Structures II** **(3-3)4**
[CE 312]

Analysis of statically indeterminate Civil Engineering structures employing classical and modern methods and treated as the initial steps in the total design concept.

CE 412 **Structures III** **(3-3)4**
[CE 411]

Design of structural elements and connections subjected to all types of stresses. Use and critical review of current design codes and application of these design principles to typical structures.

CE 413 **Concrete** **(3-3)4**
[CE 312]

Fundamental principles and concepts essential to the design and analysis of reinforced concrete structures. Research and its influence on design codes, study of elastic and inelastic behavior, and treatment of the rational foundations of design.

CE 421 Hydrology (3-3)4

Theoretical principles underlying the use of the hydrologic phenomena of precipitation and water losses in the analysis and design of hydraulic structures. Methods of estimating stream flow under normal and flood conditions.

CE 431 Soil Mechanics I (3-0)3
[CE 312]

Development of the fundamental principles of the science of soil mechanics as utilized in foundation engineering. Includes bearing capacity, percolation properties and settlement characteristics of soils as they affect the design of Civil Engineering structures.

CE 432 Soil Mechanics II (3-3)4
[CE 431]

Advanced theory of soil mechanics and its application to engineering analysis and design. Includes earth pressure theories, slope stability analysis, and the design of retaining structures and embankments. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties and behavior.

CE 961 Advanced Surveying (2-1)2
[45.32]
[For students in Engineering Technology only]

Application of higher surveying techniques to the providing of information and the solution of engineering problems. Topics covered include precise measurement of distances; precision measurement of angles; methods of determining elevations with high precision; consideration of photogrammetric techniques; and the basic principles of engineering astronomy.

CE 971 Structures (2-1)2
[25.52]
[For students in Engineering Technology only]

Review of elementary analysis of determinate structures with applications to more complex structures. Influence lines and their applications. Calculation of deflections of beams, frames and trusses. The analysis of indeterminate beams, trusses and simple frames by currently applicable methods.

CE 981 Structural Analysis and Design (3-3)4

[CE 971; 45.52]

[For students in Engineering Technology only]

Analysis and design of beams and frames. Design of structural elements under typical stresses by use of current design codes.

CE 982 Hydrology (3-3)4

[CE 961]

[For students in Engineering Technology only]

A practical treatment of the occurrence and distribution of rainfall, surface and groundwater flow. Use of hydrologic factors as components in the design of hydraulic structures.

CE 991 Concrete Analysis and Design (3-3)4

[25.53]

[For students in Engineering Technology only]

The review and extension of the application of current methods to the analysis and design of reinforced concrete structures. Use of design aids to facilitate the solution of selected problems.

CE 992 Soil Mechanics (3-3)4

[CE 971]

[For students in Engineering Technology only]

Introduction to soil mechanics including laboratory techniques, all with the emphasis on the application of principles. Encompasses the use of field and laboratory tests in the design of foundations and the treatment of highway embankments. Laboratory work includes soil classification, graduation tests, Atterberg limits, and the common soil strength and compressibility tests.

CE 994 Engineering Problems (2-1)2

[For students in Engineering Technology only]

Topical discussions covering the relationship of the engineer to such groups as the general public, governmental agencies, clients and contractors, legal entities, and other engineers. Case studies include engineering concerns in such areas as contracts and specifications, regulatory agencies including zoning boards, boards of appeals, and conservation agencies.

CE 995 **Engineering Laboratory** **(0-3)1**
[CE 971]

[For students in Engineering Technology only]

Introduction to the basic techniques in the testing of engineering materials to establish experimentally the basic stress and strain indices. Introduction to experimental stress analysis by laboratory methods.

NOTE: All numerical prerequisites will be found in the catalogue of the Division of Evening Studies.

CHEMISTRY

CH 001 **Chemical Principles** **(4-0)3**

This course includes a discussion of quantitative expressions, history of atomic and molecular theory, chemical periodicity, elementary details of atomic and molecular structure, chemical bonding, molecular geometries, resonance, organic chemistry, nomenclature, stoichiometry, introduction to acids and bases and oxidation-reduction reactions, the chemistry of oxygen, hydrogen, and water, gas laws, and thel iquid state.

CH 002 **Chemical Principles** **(4-0)3**
[CH 001]

Subject matter in CH 001 is extended to include a study of nonmetals, metalloids, and noble gases, the solid state, metals, elementary thermodynamics, solutions and colloids, chemical kinetics, chemical equilibrium, electro-chemistry, and a detailed study of acid-base phenomena.

CH 003 **Chemical Principles Laboratory** **(0-2)1**

An experimental study of chemical principles and chemical transformations. Reactions of some important elements and compounds are examined and related to the periodic table. Considerable emphasis is placed on acquainting students with techniques, methods and instruments essential to quantitative chemical measurements. Topics include methods of chemical separation, reactions, organic synthesis, formula determination and adsorption spectroscopy.

CH 004 **Chemical Principles Laboratory** **(0-2)1**
[CH 003]

A continuation of the experimentation of CH 003 including determinations of molar volume, molecular weight, reaction rate,

heat of reaction, redox potential and pH. Analytical chemistry is introduced with acid-base and oxidation reduction titrations. Careful observation and logical deduction techniques are encouraged.

CH 205 Qualitative Analysis (3-0)3
[CH 002]
[Primarily for students not majoring in chemistry.]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 207 Inorganic Chemistry (3-3)4
[CH 002]

The chemical behavior, structures, methods of preparation, and nomenclature of the more important elements and their compounds. The laboratory illustrates basic principles used in the preparation and study of inorganic compounds.

CH 210 Analytical Chemistry I (3-4)4
[CH 002, CH 221, CH 232 concurrently]
[Primarily for students majoring in chemistry]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometery, and spectroscopy.

CH 211 Quantitive Analysis (3-4)4
[CH 002]
[Primarily for students majoring in Plastics Technology]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric and volumetric analysis, including some coverage of industrial applications.

CH 221 Organic Chemistry (3-4)4

Kernel-electronic formulation, nomenclature and mechanism of reaction of the following classes of chemical species: monatomic, diatomic, multiatomic molecules and ions, alkanes, alkenes, alkynes, other non-aromatic hydrocarbons, alkyl halides, organometallics, alkanols, alkyl esters of inorganic

acids, dialkyl ethers, alkanoic acids and derivatives. The laboratory work consists of practice in planning and carrying out reactions to form products isolatable by distillation.

CH 222 Organic Chemistry (3-4)4
[CH 221]

Formulation, nomenclature, mechanism of reaction, and overall equations for property reactions of the following classes of compounds: aldehydes; ketones; amines; organosulfurs; carbonic acid derivatives; multihydroxyaldehydes and derivatives including stereochemistry; carbohydrates; arenes; aryl halides; arenesulfonic acids; nitroarenes; arylamines; phenols; quinones; aromatic aldehydes, ketones, alcohols and carboxylic acids; multicyclic aromatic hydrocarbons and derivatives; heterocyclics and alkaloids. The laboratory work consists of instruction and practice in planning and successfully carrying out reactions to form solid products isolatable by crystallization.

CH 223 Introductory Organic Chemistry I (3-3)4
[Primarily for students not majoring in chemistry]

Lectures in this course will include discussions of structures (with emphasis on molecular orbital theory and stereochemistry), classification by functionality, nomenclature, syntheses, and reactions and reaction mechanisms of organic compounds. The laboratory phases of the course work will be devoted to product separation and purification techniques, and methods of synthesis of industrially important organic compounds.

CH 224 Introductory Organic Chemistry II (3-3)4
[CH 223]

A continuation of the first semester subject (CH 223).

CH 232 Physical Chemistry (3-3)4
[MA 203]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 311 Analytical Chemistry II (2-4)3
[CH 210, CH 222, CH 333 concurrently]

The lecture consists of an introduction to simple and complex equilibria, kinetics, fundamentals of instrumentation and

the chemical and instrumental bases of the tools of modern chemical analysis.

The laboratory furnishes instruction in fundamental analytical techniques from gravimetric and volumetric methods to use of modern instrumental techniques to separate, purify and determine the structure of unknown organic and inorganic compounds.

CH 321 Organic Chemistry Laboratory II (1-6)3
[CH 222]

A continuation of CH 222 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 333 Physical Chemistry (3-3)4
[CH 232]
[For chemistry majors only]

Introduction to principles of statistical mechanics, kinetics, electrochemistry, and atomic and molecular structure.

CH 335 Principles of Physical Chemistry (3-3)4
[MA 203]

Similar to CH 232 and 333 but designed for students not majoring in Chemistry.

CH 336 Principles of Physical Chemistry (3-3)4
[CH 335]

A continuation of CH 335.

CH 342 Organic Qualitative Analysis (1-6)3
[CH 222]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403 Chemistry of High Polymers (3-4)4
[CH 222 or 224; CH 333 or 336]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization

as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereo-specific polymers, the chemistry of the more common polymers systems, and preparation of their corresponding monomers.

CH 404 Chemistry of High Polymers (3-4)4
[CH 403]

A continuation of CH 403.

CH 407 Undergraduate Thesis (0-9)3

[Permission of Department Head and Instructor]
Open only to Seniors majoring in chemistry. Research in analytical, organic, inorganic, physical, and polymer chemistry.

CH 408 Undergraduate Thesis (0-9)3

A continuation of CH 407. Both semesters must be taken and not more than six credits indicated may be used in meeting degree requirements. Letter grades are given in both semesters. A written thesis is required following the conventional form of introduction, literature survey, results and conclusions. One copy of the thesis must be filed with the department office.

CH 409 History of Chemistry (1-0)1

A seminar course devoted to the discussion of the historical development of chemical principles. Each student is required to present to the class a paper for discussion.

CH 411 Advanced Analytical Chemistry (2-4)3

Identical with CH 311 which replaces it effective for the class of 1972.

CH 413 Nuclear Magnetic Resonance and Electron Spin Resonance Spectroscopy (3-0)3
[CH 432]

An introduction to the essentials of nuclear and electron spin resonance is presented to illustrate the scope and application of the method. May be taken for graduate credit.

CH 423 Advanced Organic Chemistry (3-0)3
[CH 222]

Extension of introductory organic chemistry for chemistry majors. Organic compounds and reactions are discussed in terms of reaction mechanisms, structure-reactivity and sterochemistry.

CH 424 Advanced Organic Chemistry (3-0)3
[CH 222]

Synthesis of organic molecules. Selected reagents and techniques are discussed with emphasis on the scope and limitations of these reactions. The reaction mechanisms are also discussed.

CH 431 Advanced Physical Chemistry (3-0)3
[CH 333 or equivalent]

An extension of introductory physical chemistry for undergraduate majors and first-year graduate students in chemistry and related fields, with emphasis on classical and statistical thermodynamics as they apply to the various chemical phenomena.

CH 432 Advanced Physical Chemistry (3-0)3
[CH 431]

A continuation of CH 431.

CH 434 Colloid and Surface Chemistry (3-0)3
[CH 232 or CH 335]

Theory of colloidal systems including physical chemistry of surfaces, electrokinetic phenomena and molecular kinetic and optical properties of colloids. Consideration is also given to thin layers and to foams and emulsions including the preparation of lyophobic colloidal systems, and the stability of lyophobic sols.

CH 442 Advanced Inorganic Chemistry I (3-0)3
[CH 333]

A theoretical treatment of the structure of the atom and inorganic compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics, theories of the chemical bond, crystal field theory, ligand field theory, and inorganic stereochemistry.

CH 443 Advanced Inorganic Chemistry II (3-0)3

A continuation of CH 442 with emphasis on the dynamics of inorganic systems. Reactions in aqueous solvents. Thermodynamics of coordination compounds. Kinetics of fast reactions with such topics as stopped-flow, temperature jump techniques.

CH 481 Radiochemistry (2-3)3
[CH 002, MA 204, PH 202]

An introduction to the fundamentals of radioactivity and radiochemistry. The laboratory work is directed to the detection and measurement of radioactivity. Designed primarily for majors in chemistry and allied fields.

CH 482 Radiochemistry (2-3)3
[CH 481]

A continuation of CH 481 with emphasis on the applications of chemical principles and practices toward the separation of radioisotopes. The laboratory experiments are designed to use such well-known techniques of separation as solvent extraction, precipitation, coprecipitation, and electrochemical displacement toward this end.

CH 484 Elements of Radiochemistry (2-3)3

Chemical principles are reviewed and their applications to radiochemistry are discussed. Such topics as separation procedures and chemical identification of nuclides, radiation chemistry, and study of fission products are included in the course.

CH 502 Absorption Spectrophotometry and Color Measurement (2-3)3

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503 Chemistry of High Polymers (3-0)3
[CH 222; CH 333]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 504 Chemistry of High Polymers (3-0)3
[CH 503]

A continuation of CH 503.

CH 505 Techniques of Polymer Chemistry (0-4)1

A laboratory subject to be taken concurrently with CH 503 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 506 Techniques of Polymer Chemistry (0-4)1

A continuation of CH 505.

CH 509 Introduction to Polymer Physics (3-0)3

Elements of chain statistics, bonding in polymers, segmental and molecular motion. First and second order transitions and the glass transition temperature. Rubber elasticity. Viscoelasticity and mechanics of network response. Electrical and optical properties of polymers. Crystalline state in polymers.

CH 510 Introduction to Macromolecular Biophysics (3-0)3

Methods of determination of the size and shape of biomacromolecules in the liquid and in the condensed state. Physics of albumins: primary, secondary and tertiary structures. Physics of the nucleic acids. Memory effects in biomacromolecules and the problem of the genetic code. Biomacromolecular activity and biological specificity. Mechano-chemical and electro chemical activity of biomacromolecules.

CH 511 Spectroscopy (3-0)3
[CH 431 and 432]

A presentation of molecular spectra and molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results.

CH 514 Advanced Analytical Chemistry (3-0)3
[CH 431 or equivalent]

An emphasis is placed on the determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions.

CH 515 Chemical Literature (1-0)1

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding, assembling and using such data.

CH 516 Advanced Laboratory Technique (1-3)2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 517 Glass Working (0-1)0

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 521 Physical Organic Chemistry (3-0)3

Modern and Classical Methodology in the study of organic reactions. Fast reactions, linear free energy relationships, tracer methods, instrumental techniques and other selected topics will be covered.

CH 522 Physical Organic Chemistry (3-0)3
[CH 424]

This is a course in theoretical organic chemistry. General topical coverage includes polarization effects, intermolecular forces including hydrogen bonding, reactivity indices, transition state theory and activation parameters, electronically excited organic molecules, isotope effects, stereoselection in elementary organic reactions, and selected special topics.

CH 523 Organic Reaction Mechanisms and Structures (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 Organic Synthesis (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate students only.

CH 527 Stereochemistry (3-0)3

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.
Offered in alternate years.

CH 531 Statistical Mechanics for Chemists (3-0)3
[CH 539 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 535 Advanced Topics in Physical Chemistry (3-0)3

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Thermodynamics (3-0)3
[CH 539 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 539 Theoretical Chemistry (3-0)3
[CH 433 or equivalent]

The formal and group theoretical aspects of quantum chemistry particularly as they apply to molecular structure and reactivity.

CH 540 Chemical Kinetics (3-0)3
[CH 443 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 543 Modern Inorganic Chemistry I (3-0)3
[CH 333 or equivalent]

Similar to CH 443 but designed specifically for graduate students. Emphasis is placed on the theoretical-physical concepts of importance to inorganic chemists.

CH 544 Modern Inorganic Chemistry II (3-0)3
[CH 543]

A continuation of CH 543 with emphasis on the mechanisms of inorganic reactions.

CH 549 Physical Chemistry of Macromolecules I (3-0)3
[CH 503 or CH 509]

An advanced treatment of the physical chemistry of ma-

cromolecules including chain statistics, thermodynamics and optical and hydrodynamic properties.

Offered in alternate years.

CH 551 **Physical Chemistry of Macromolecules I** **(3-0)3**
[CH 503 or CH 509]

An Advanced treatment of special topics in the physical chemistry of macromolecules such as the study of polyelectrolysis solutions, transport processes in the presence of an electric field, multiple equilibria, and the kinetics of macromolecular reactions.

Offered in alternate years.

CH 553 **Organic Chemistry of Macromolecules** **(3-0)3**
[CH 404]

An advanced study in polymer science concerned with modern theoretical concepts and including synthesis, mechanism of formation, reactions and degradation of macromolecules.

Offiered in alternate years.

CH 554 **Stereochemistry of Macromolecules** **(3-0)3**
[CH 404, CH 424]

A treatment of modern methods applicable to the stereochemistry of macromolecules and including homogeneous and heterogeneous catalysis, methods of analysis, synthesis, mechanism, structural consequences generated from geometry, configuration or conformation and a statistical treatment of tacticity.

Offered in alternate years.

CH 561 **Advanced Organic Synthesis** **(3-0)3**
[CH 523 and 524, or equivalent]

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids, antibiotics. Theoretical implications of organic reactions are also discussed.

Offered in alternate years.

CH 564 **Organic Qualitative Analysis** **(1-6)3**

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy.

CHEMICAL ENGINEERING

CN 203 Introduction to Chemical Engineering (2-0)2
[CH 002, MA 104]

Introduction to the fundamentals of chemical engineering. Curve plotting, introduction to chemical equilibria and kinetics. Development of flow sheets and introduction to mass balances. Review of chemical reactions and analysis of two processes.

CN 204 Chemical Engineering Calculations (3-0)3
[CN 203, MA 204 taken concurrently]

Mass and Energy balances, including phase separation and elementary thermochemistry. Steady-state calculations and applications to chemical engineering processes. Introduction to unsteady-state concepts.

CN 206 Fluid Mechanics (2-0)2

Introduction to fluid statics and application of fluid mechanics principles to the analysis of and design of fluid systems. Design of fluid meters and conduits. Friction factor, pressure drops in laminar and turbulent flow and introduction to boundary layer theory.

CN 208 Chemical Engineering Laboratory I (0-3)1
[CN 203]

Introduction to chemical engineering concepts. The material balances, reaction rates, and orders of reactions. Phase separations and development of elementary unit process concepts.

CN 303 Transfer Operations I (3-0)3
[CN 204]

Energy transport by conduction, convection, and radiation, steady state and unsteady state in one and multi-dimensional systems. Equations of motion are derived for use in convection and design equations are then developed for heat exchangers, condensers and other process heat transfer equipment.

CN 304 Transfer Operations II (3-0)3
[CN 204]

Application of phase equilibria to design methods for stage-wise operations. Specific reference is made to Distillation, Absorption, Extraction and Humidification.

CN 311 Chemical Engineering Thermodynamics (3-0)3
[CN 303 taken concurrently]

Application of the First and Second Laws of Thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 312 Chemical Engineering Thermodynamics II (3-0)3
[CN 311]

A detailed rigorous treatment of topics not covered in CN 311. Additional material on general thermodynamic relations are developed for use in application of non-ideal gases and real substances. Interpretation of phase equilibrium data and applications are covered, as well as an introduction to statistical thermodynamics.

CN 315-316 Chemical Engineering Laboratory II and III (0-3) (0-3)2
[CN 303 and CN 304 taken concurrently]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports. Application of chemical engineering principles.

CN 319 Special Projects Credits to be arranged

Research projects to be undertaken by the student with the supervision of a staff member. Usually will be an original problem. Reports required on project work.

CN 403 **Reactor Design and Kinetics** **(3-0)3**
[CN 304]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems. May be taken for graduate credit.

CN 405 **Transport Phenomena** **(3-0)3**
[CN 304 or Permission of Instructor]

Review of transport mechanisms, shell momentum, energy and mass balances. Careful definition of transport coefficients, equations of continuity, motion and energy for steady and transient processes. Macroscopic balances applied to systems of interest and solutions to problems are emphasized. May be taken for graduate credit.

CN 407 **Engineering Analysis of Chemical Processes** **(3-0)3**
[CN 304]

A qualitative and quantitative analysis of selected chemical processes from a chemical engineering and economic viewpoint. Interrelationships between various segments of the industry. Reports and plant visits. May be taken for graduate credit.

CN 408 **Material Science** **(3-0)3**
[Approval of Instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures. Corrosion and elementary electrochemistry. Structures of metals, non-metals and polymeric materials. Structure of materials related to performance. May be taken for graduate credit.

CN 410 **Process Analysis and Plant Design** **(3-0)3**
[CN 304, CN 316]

Economic principles applied to evaluation and optimization of various chemical engineering processes. Several minor projects and one major design problem requiring written reports and oral presentation. Use of computers in design, computations. May be taken for graduate credit.

CN 414 Process Dynamics and Control (3-0)3
[CN 204, MA 204]

An introduction to chemical process control, description of processes and equipment by differential equations and the LaPlace transform. Representation of open and closed loop by block diagrams. Control loop stability is discussed together with methods of representing dynamic behavior on Bode and Nyquist diagrams and related to experimental data. May be taken for graduate credit.

CN 416 Profession Orientation (1-0)1

A series of lectures and discussion groups primarily with seniors and graduate students to acquaint them with the mechanics of business, finance and taxes, unionism, organization of businesses and what is expected by industry and society of a professional engineer.

CN 419 Special Senior Projects Credits to be arranged

Original research projects primarily in the chemical engineering field and supervised by a staff member of the Department. Reports required on work done.

CN 503 Absorption and Extraction (3-0)3
[CN 304]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems. Use of computer in some problem solutions.

CN 506 Colloid Chemistry for Chemical Engineers (3-0)3

Colloid chemistry principles applied to chemical engineering processes. Zeta potential and its applications; special problems involving surface chemistry and physics.

CN 507 Corrosion and Electrochemical Principles (2-0)2
[Approval of Instructor]

Electrochemical principles and physical chemistry relating to corrosion of metals. Materials of construction and desgin based on these principles. Prediction of metal behavior in process design.

CN 510 Water Resources Management (3-0)3
[Approval of Instructor]

A study of all actual and potential sources of potable and industrial water is made, giving particular attention to origin, chemical composition and possible sources of contamination. Methods of purification of water including reclamation of saline waters are studied in detail, particularly from a chemical engineering standpoint. Economic factors of purification and water distribution are also studied.

CN 511 Structure and Properties of Matter (3-0)3
[Approval of Instructor]

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering. Micro and macro structures related to end-use performance.

CN 517 Advanced Distillation (3-0)3
[CN 503]

Review of principles of mass separation. Multicomponent distillation. Design of columns and analysis of specific systems. Use of computers in solution of distillation problems.

CN 519 Advanced Chemical Engineering Thermodynamics (3-0)3
[CN 312]

A critical examination of classical thermodynamics from a chemical engineering viewpoint, emphasizing the fundamental laws. General thermodynamic relations are used to develop equations for pure, ideal gases and real substances. Selected topics in applications of thermodynamics to equilibrium systems, refrigeration and other equipment.

CN 521 Introduction to Environmental Engineering (3-0)3
[Approval of Instructor]

This course introduces the student to the problem of the magnitude and causes of environmental pollution, in all of its aspects. The problems of water and air pollution are given particular emphasis and the student is given special projects for investigation. The course covers primarily the assessment and evaluation of the magnitude of the problem but does not consider the known or possible solutions to the problem of environmental pollutions.

CN 522 Environmental Waste Management (3-0)3
[Approval of Instructor]

A detailed study is made of the various sources of wastes and pollution from municipal and industrial sources. The first part of the course emphasizes current methods of waste control and purification of waste waters with particular emphasis on the chemical engineering aspects of the technology. The last part of the course is involved with the present technology of handling of gaseous waste systems. Economic factors are emphasized and special projects are given for outside study.

CN 523 Air Resources Use and Control (3-0)3
[Approval of Instructor]

This course emphasizes the problems involved in air pollution and the technology developed for its control. Methods of analysis and the technologies of removing gaseous contaminants and particulate solids from waste gas streams are emphasized. The chemical engineering aspects of these techniques constitute a major portion of the course.

CN 527 Legal and Social Aspects of Environmental Pollution Reviews (3-0)3
[Approval of Instructor]

This course reviews the laws relating to air and water quality and to the social aspects of control of these parts of man's environment, environmental engineering and the control of environmental pollution. Such topics as the control of oil wastes in an ocean environment, specialized chemical discharges such as cyanides and other chemical wastes and thermal wastes from power plants are investigated. In all cases considerable emphasis is placed on the chemical engineering aspects of these pollution problems and their control. Special topics in the local area of real importance will also be considered.

CN 528 Intermediate Transport Phenomena (3-0)3
[Approval of Instructor]

An advanced study of the mechanics of momentum, heat and mass transfer. The equations of continuity, motion and energy are considered for several systems in steady and unsteady state processes. Transfer coefficients are defined as a microscopic and macroscopic level and the entire subject of unit operations are defined in terms of equations of change. Considerable emphasis is placed upon solutions to problems.

CN 538 Special Environmental Engineering Projects Credits to be arranged
[Approval of Instructor]

DATA PROCESSING

DP 930 Scientific Computer Programming — FORTRAN (2-1)2

[MA 41]

[For students in Engineering Technology only]

A detailed study of the FORTRAN programming language for the Institute's computer with numerous mathematical examples and problems; introduction to advanced programming techniques and large data processing systems. Student will program several basic problems to completion.

ECONOMICS

EC 201 Economics I (3-0)3

The foundations and nature of economic principles. Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 202 Economics II (3-0)3

National income, money and banking, and monetary and fiscal policy.

EC 211-212 Economic Statistics I and II (3-0) 3-0)6

Measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development (3-0)3

A study of the history of economic development of the developed economics with primary emphasis on the United States.

EC 302 Labor Economics (3-0)3

[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 **Microeconomic Theory** **(3-0)3**
[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 **Macroeconomic Theory** **(3-0)3**
[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 402 **Government and Business** **(3-0)3**
[EC 202]

An examination of federal, local and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 **International Trade Theory** **(3-0)3**
[202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 **Comparative Economic Systems** **(3-0)3**
[EC 202]

Income distribution and resource allocation in centrally-planned as opposed to market-oriented economics. Emphasis on output decisions, role of price, problems of consistency and efficiency, success indicators, and incentives.

EC 407 **Econometrics** **(3-0)3**
[EC 212, 304]

The course will provide the student both theoretical and empirical knowledge of econometrics. Methods of handling data, quantative empirical estimates, and tests of economic theory.

EC 408 **History of Economic Thought** **(3-0)3**
[EC 303]

Analysis of the development of economic theory; emphasis on the rise of classical economic thought.

EC 409 National Income and Business Cycles (3-0)3
[EC 202]

Analysis of the relationship between national income, total spending and the price level. The nature and cause of changes in the level of business activity. Business cycle theories, forecasting and the problems of instability.

EC 410 Economic Development of Less Developed Countries (3-0)3
[EC 202]

The role of capital (private and social), technology, labor, governments, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 Public Finance (3-0)3
[BA 332]

Study of alternative methods of financing non-market enterprises. Special emphasis on the tax and expenditure policies of federal, state and local governments.

EC 412 Managerial Economics (3-0)3
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 414 Engineering Economy (3-0)3
[EC 202]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

EC 500 Research Seminar (3-0)3
[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.

ELECTRICAL ENGINEERING

EE 201 Introductory Circuit Theory I (4-0)4
[MA 104 and PH 201 concurrently]

Terminal characteristics of ideal elements, active and passive. Ohm's Law and Kirchoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis. Definition and consequences of linearity, superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits, Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics, energy relations, graphical differentiation and integration. First-order transients: initial conditions, natural response and natural frequencies. Network response to unit step function and unit impulse.

EE 202 Introductory Circuit Theory II (4-0)4
[EE 201]

Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane. Sinusoidal forcing function, complex numbers, phasors, sinusoidal steady-state. Average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton's theorems, superposition, reciprocity, maximum power and Tellegen's theorem. Magnetic coupling, mutual inductance, ideal transformer. Impedance and admittance and hybrid parameters for a two-port network. Introduction to matrices and their use in circuit analysis.

EE 207 Basic Electrical Engineering Laboratory I (1-3)2
[EE 201 concurrently]

Primarily devoted to experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 208 Basic Electrical Engineering Laboratory II (1-3)2
[EE 207]

Continuation of EE 207

EE 221 Fundamentals of Electricity (3-0)3
[MA 104, PH 201 concurrently]
[Not open to students majoring in Electrical Engineering]

An introduction to electric circuits. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]

[Not open to students majoring in Electrical Engineering]
A background subject in electronics presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211]

[Not open to students majoring in Electrical Engineering]
An introductory laboratory course primarily devoted to the measurement of terminal characteristics of electrical machinery.

EE 306 Electromagnetic Theory (4-0)4
[MA 313]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials; time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 311 Electronics Laboratory I (1-3)2
[EE 208; EE 319 concurrently]

An intermediate course primarily devoted to laboratory exercises in which the experiments are designed to stimulate an appreciation for the limitations of basic electronic equipment. The experiments are closely coordinated with allied courses and provide experimental verification of the properties of electronic devices and circuits.

EE 312 Electronics Laboratory II (1-3)2
[EE 311 and EE 320 concurrently]

Continuation of EE 311.

EE 315 Signal and System Analysis (4-0)4
[EE 202, MA 204]

Natural and forced response of linear systems; exponential excitation, impulse response, and system function. Orthogonal functions, Fourier series analysis, impulse method of coefficient evaluation. Fourier transforms, complex Fourier transforms and Laplace transforms and frequency analysis of linear systems. Causality and Paley-Wiener criterion, distortionless ideal filters. Natural frequencies related to poles and zeros of pertinent impedances. Time-convolution applied to system analysis. Frequency-convolution applied to power spectra, modulation and sampling.

EE 318 Digital Computation in Electrical Engineering (3-3)4
[EE 201 or EE 211]

The application of digital computers to the solution of electrical engineering problems with emphasis on compiler languages such as FORTRAN. Example problems are chosen to parallel material treated in other electrical engineering courses where possible. Computer aided circuit design and digital simulation techniques are introduced with specific examples in ECAP and PACTOLUS.

EE 319 Electronics I (4-0)4
[EE 202 and PH 201]

Ebers-Moll models of the transistor from basic principles of field theory. Introduction to the fundamental concepts of electronics including break point analysis, piecewise linearization, active circuit theory and incremental analysis.

EE 320 Electronics II (4-0)4
[EE 319]

A detailed study of electronic circuit design including operating point stability, h parameters, cascading of stages, frequency response of linear amplifiers, feedback amplifiers and other topics.

EE 321 Electrical Energy Conversion (3-0)3
[EE 211, MA 203]

[Not open to students majoring in Electrical Engineering]
The generation, control, utilization and conversion of electrical energy.

EE 348 Basic Electrical Engineering Concepts (3-0)3

[MA 104]

[Not open to students majoring in Electrical Engineering]

An introduction to the basic principles of electricity; including the concept of voltage, current, resistance, inductance and capacitance; Ohm's and Kirchoff's Laws; Thevenin's and Norton's Theorems. Emphasis will frequently be placed on pointing out analogous problems in the chemical and mechanical engineering fields. Other areas of coverage will include transient and sinusoidal steady state analysis of RLC circuits, motor and generator concepts and an introduction to solid state devices including the semiconductor diode and transistor.

EE 351 Industrial Electronics (3-0)3

[For students majoring in Industrial Management only]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum tube, gaseous-tube and semiconductor device characteristics and of circuits utilizing such devices for the purpose of rectification, amplification and oscillation; and industrial photo-electric and time delay relays.

EE 353 Electrical Controls and Power Circuits (3-0)3

[MA 203]

[Not open to students majoring in Electrical Engineering]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and generators; manual and automatic electric controls including photoelectric relays, time delay relays and motor control.

NOTE: Courses in the 400 Series may be taken for graduate credit upon approval of the student's advisory committee.

EE 403 Microwave Electronics (3-0)3

[EE 306]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 409 **Applied Electronics Laboratory I** **(0-4)2**
[EE 312]

The purpose of this laboratory is to give the student an experimental familiarity with the nature, application and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of technical reports.

EE 410 **Applied Electronics Laboratory II** **(0-4)2**
[EE 409]

Continuation of EE 409

EE 411 **Logical Design of Digital Computers I** **(3-0)3**
[EE 319]

Foundations for the complete design of digital computer subsystems, such as the arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuity as well as the logical tools: flip-flops, shift-registers, logical gates, and magnetic core memories. Boolean algebra, system synthesis, coding, and error detection.

EE 412 **Logical Design of Digital Computers II** **(3-0)3**
[EE 411]

Continuation of EE 411

EE 413 **Linear Feedback Systems** **(3-0)3**
[EE 315]

Mathematical models of feedback systems, system characteristics and performance specifications stability; analysis techniques including root locus, log magnitude and phase diagrams, the Nyquist and Nichols plots.

EE 414 **Feedback Control Systems** **(3-0)3**
[EE 413]

Time domain analysis of feedback control systems, compensation, Truxal's synthesis procedure, complex control systems and a.c. carrier systems.

EE 416 Electronic Amplifier Circuits (3-0)3
[EE 320, EE 413]

An integrated treatment of the analysis and design of vacuum tube and transistor amplifier circuits with emphasis on the design of such circuits. The majority of circuits considered are of the small-signal category, i.e., Class A operation.

EE 417 Absolute and Symbolic Programming (3-0)3
[EE 318]

A study of machine language and assembly language programming of the modern high speed binary computer. In addition to mathematical problem solving techniques, the use of on-line computers in data acquisition and process control is treated. Students are expected to prepare and personally process programs on the HP 2116B binary computer. Although this course is open to all qualified students, it is primarily intended as an introductory course in computer science for electrical engineering majors.

EE 425 Wave Shaping and Generation I (3-0)3
[EE 320]

Principles and methods of wave shaping and wave generation using active and passive elements. Timing, switching, memory devices, oscillation, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjunction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 426 Wave Shaping and Generation II (3-0)3
[EE 425]

Continuation of EE 425

EE 429 Network Synthesis (3-0)3
[EE 315, MA 313]

A review of methods of analysis useful in the study of signals; systems and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to the design of networks having prescribed driving-point and transfer characteristics.

EE 435 **Special Topics in Electrical Engineering I** **(3-0)3**

[Permission of Instructor]

An analytic consideration of one or more special topics selected from recent developments in the field of electrical engineering.

EE 436 **Special Topics in Electrical Engineering II** **(3-0)3**

[EE 435]

Continuation of EE 435

EE 439 **Introduction to Electrical Systems** **(3-0)3**

[EE 315 and EE 320]

An introduction to both power and communication systems, including distributed constant transmission lines, power system operation, communication systems using amplitude, angular and pulse modulation, and a survey of radio propagation.

EE 440 **Electrical Communication Systems** **(3-0)3**

[EE 439]

A continuation of the study of communication systems including the statistical properties of signals and noise, data transmission, error detection and correction, signal to noise ratio and channel capacity of various systems.

EE 444 **Electrical Power Systems** **(3-0)3**

[EE 439, EE 454 concurrently]

Design and operation of present-day power networks considered both from the viewpoint of economy and reliability including the problems of power and frequency control, system stability and fault analysis.

EE 445 **Analog Devices and Techniques** **(3-0)3**

[EE 319]

A survey of analog devices and techniques. Primary emphasis is on general techniques although conventional analog computers are discussed extensively as examples of the application of the techniques. Operational amplifiers, multipliers, amplitude and time scaling.

EE 446 **Digital Devices and Techniques** **(3-0)3**
[EE 319]

A survey of digital devices and techniques. Primary emphasis is on general techniques although conventional digital computers are discussed extensively as examples of the application of the techniques. Machine organization, number systems, Boolean algebra, arithmetic operations, memory devices, analog to digital conversion, and digital to analog conversion are discussed.

EE 454 **Electromechanics** **(3-0)3**
[EE 202 and MA 204]

The principles of electromechanical energy conversion applied to rotating machinery, control systems, and devices such as microphones, loudspeakers, accelerometers, servomotors, and space vehicles. A first course for the student of electrical engineering who will use rather than design electromechanical devices.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well-qualified undergraduate students.

EE 503 **Solid-State Physical Electronics I** **(3-0)3**
[EE 320]

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 504 **Solid-State Physical Electronics II** **(3-0)3**
[EE 503]

Continuation of EE 503

EE 505 **Microwave Electronics I** **(3-0)3**
[EE 306]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 506 — Microwave Electronics II — (3-0)3

[EE 505]

Continuation of EE 505

EE 507 — Electromagnetics I — (3-0)3

[EE 306]

Solution of Laplace's and Poisson's equations in rectangular, cylindrical and spherical coordinates. Green's function and conformal transformations. Also boundary value problems, radiation, transmission lines and wave guides will be treated.

EE 508 — Electromagnetics II — (3-0)3

[EE 507]

Continuation of EE 507

EE 509 — Systems Analysis-Transform Techniques — (3-0)3

[EE 315]

Theory of functions of a complex variable. Applications of transform calculus to the solution of differential equations which arise in the treatment of mechanical, acoustical, thermal and electrical systems.

EE 510 — Systems Analysis-State Variable Techniques — (3-0)3

[MA 533]

State variable formulation and solution of differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems with consideration of canonical forms for computer simulation.

EE 515 — Nonlinear Control Systems — (3-0)3

[EE 413]

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function, the methods of Lyapunov and Popov and other nonlinear analysis techniques are treated.

EE 517 — Optimal Control Systems — (3-0)3

[EE 413]

A study of the analysis and design of optimal control systems. Both deterministic and random input signals are discussed. Introduction to adaptive control systems.

EE 519 Sampled-Data Control Systems (3-0)3
[EE 413]

The sampling process, reconstruction of sampled signals, the Z transform. Block diagram and signal flow graph representation of sampled-data systems and the time response of such systems.

EE 521 Automata Studies (3-0)3
[EE 412]

Mathematical foundation of automata, including probabilistic logics, neuron analogs, Turing machines, and learning theory.

EE 523 Digital Computer Software (3-0)3
[EE 417]

A discussion of formal languages and translators with particular reference to assemblers, and compilers. Student programs are executed on available digital computers.

EE 525 Simulation Techniques (3-0)3
[EE 318; EE 445]

A study of modern analog, digital and hybrid techniques for the simulation of continuous and discrete systems and processes. The student is expected to study a number of practical engineering systems through the use of simulation techniques on available analog and digital computers.

EE 529 Network Synthesis I (3-0)3
[EE 315]

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 530 Network Synthesis II (3-0)3
[EE 529]

Continuation of EE 529

EE 537 Introduction to Bio-Medical Engineering (3-0)3
[EE 320]

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed.

EE 539 Biological Systems (3-0)3
[EE 413, EE 445; EE 537]

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required.

EE 545 Coding Theory (3-0)3
[MA 533]

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail.

EE 547 Statistical Communication Theory (3-0)3
[MA 584]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 584]

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

EE 549 Introduction to Lasers and Masers (3-0)3
[EE 306 or PH 353; EE 403]

A first course on Lasers and Masers not requiring quantum mechanics as a prerequisite. Classical electric and magnetic dipole models are developed to describe the quantum interaction between atoms or molecules and the radiation field. This course is designed to prepare the student to read the literature on the subject.

EE 551 Electro-Optics (3-0)3
[EE 306, EE 315; EE 549]

Principles of optical propagation as described by the Fresnel-Kirchoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 552 **Electro-Optics II** **(3-0)3**
[EE 551]

Continuation of EE 551

EE 975 **Basic Electricity** **(3-3)4**
[PH 942, 45.41]
[For Engineering Technology students only]

An introduction to electric circuits for students who have a background in basic principles of electricity and magnetism. Includes illustrative laboratory projects.

EE 978 **Basic Electronics** **(3-0)3**
[EE 975]

[For Engineering Technology students only]
A background subject in electronics presenting the properties and applications of vacuum tube and semiconductor devices. Intended for the student who will use rather than design electronic circuits.

INDUSTRIAL MANAGEMENT

IM 371 **Operations Research** **(3-0)3**

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 372 **Production Problems** **(3-0)3**
[BA 371]

A quantitatively oriented case course stressing the functional interrelationship of major manufacturing decisions facing management. Emphasis will be placed on problems of operations management, including scheduling, inventory control and facilities design, and methods of implementation, applied theory of mathematical programming, simulation, statistical models and organizations design.

IM 483 **Statistical Quality Control** **(3-0)3**
[MA 383 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 500 Research Seminar 3
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

Languages and Literature

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 209 Technical and Scientific Communication (3-0)3
[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature: to 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature: from 1865 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature: to 1865 (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature: from 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English literature from 1798.

LL 218 Negro-American Literature (3-0)3
[LL 111-112]

A study of poems, plays, short stories and novels by Negro-Americans from 1920 to the present, including Langston Hughes, Richard Wright, James Baldwin, Ralph Ellison, and others.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 259-260 Elementary German (3-0) (3-0)6

Fundamentals of grammar and basic vocabulary. Audio-lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use. No credit for the first semester without the second.

LL 261-262 Elementary Technical German (3-0) (3-0)6

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. No credit for the first semester without the second.

LL 263-264 Elementary French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary school training in French.

LL 265-266 Elementary Russian (3-0) (3-0)6

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use. No credit for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing skills in reading and writing. No credit for the first semester without the second.

LL 269-270 Elementary Modern Greek (3-0) (3-0)6

The fundamentals of the language will be studied with emphasis on vocabulary, reading, and writing. Stress will also be given to oral expression. No credit for the second semester without the first semester or its equivalent.

LL 311 Advanced Composition (3-0)3
[LL 111-112]

An intensive course in the rhetorical modes of exposition, with emphasis on argumentation. Students will present and defend papers every two weeks.

LL 313 Introduction to Continental Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 315 Myth and Symbol in Literature (3-0)3
[LL 111-112]

An examination of the use of myth and symbol in modern literature for its thematic and cultural-historical significance. Emphasis on the analysis literature selected from the works of Dostoevski, Gide, Mann, Conrad, D. H. Lawrence and others.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 333 Problems of Philosophy (3-0)3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 341 Satire (3-0)3
[LL 111-112]

A study of a literary genre. Selected readings from Horace and Juvenal through Orwell and Burgess.

LL 344 Modern Poetry (3-0)3
[LL 111-112]

An inductive investigation into the trends of modern American and British poetry, with emphasis on Hopkins, Yeats, Frost, Eliot, Stevens, and Williams.

LL 345 Modern Irish Literature (3-0)3
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 Intermediate French (3-0) (3-0)6
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit. No credit for the first semester without the second.

LL 365-366 Intermediate Literary and Conversational Russian (3-0) (3-0)6
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records. No credit for the first semester without the second.

LL 367-368 Intermediate German (3-0) (3-0)6
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idiomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of significant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use. No credit for the first semester without the second.

LL 369-370 Intermediate Spanish (3-0) (3-0)6
[LL 268 or equivalent]

Intensified study of the language, with increased opportunity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits. No credit for the first semester without the second.

LL 435 English Literature of the Eighteenth Century (3-0)3
[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectual background.

LL 436 English Romantic Poets (3-0)3
[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

LL 437 English Literature of the Victorian Period (3-0)3
[LL 111-112]

Consideration of selected poetry and prose of the Victorian age. Readings, lectures, and discussion.

LL 444 Popular Culture (3-0)3

A study of the Hero in American popular culture. Selected heroes include the Cowboy, the Tough Guy, the Secret Agent, the Politician, the Black, and the Musician. Movies, records, magazines, TV, and popular literature will be used.

LL 467 Seminar in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3
[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 Nineteenth-Century British Novel (3-0)3
[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 482 The American Short Story (3-0)3
[LL 111-112]

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

LL 495 Reading and Research (3-0)3
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideration for admission limited to Juniors and Seniors with "B" average.

LL 961 British Literature (3-0)3

[For students in Engineering Technology only]
An introduction to British Literature from the Anglo-Saxon Period to the Contemporary Period, with emphasis on major authors and key periods.

LL 962 American Literature (3-0)3

[For students in Engineering Technology only]
An introduction to the literature of the United States from the Colonial Period to the Contemporary Period, with emphasis on major authors and historical background.

MATHEMATICS

MA 101 Mathematical Analysis I (3-0)3

Review of algebra, factoring, rectangular coordinates, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, variation, mathematical induction, progressions, approximate numbers, logarithms, mathematics of investment, trigonometric functions of acute angles, solution of right triangles, and logarithmic solution of right triangles.

MA 102 Mathematical Analysis II (3-0)3
[MA 101]

Trigonometric functions of any angle, solution of oblique triangles, trigonometric formulas and identities, radian measure, trigonometric curves, trigonometric equations, complex numbers, polynomials, equation and locus, straight line, circle, parabola, ellipse, hyperbola, curve sketching, parametric equations, curve fitting, permutations and combinations, probability and determinants.

MA 103 Calculus I (3-0)3

Functions and graphs, equations of straight lines, the conics, the differentiation of algebraic functions together with

applications involving tangent lines and velocity and acceleration, scalar product of two-dimensional vectors, the indefinite integral and area under a curve.

MA 104 Calculus II (3-0)3
[MA 103]

Applications of differentiation involving related rates, differentials, maxima and minima; methods of integration including parts, trigonometric substitution and partial fractions; the differentiation and integration of exponential, logarithmic and trigonometric functions; hyperbolic functions, and parametric equations.

MA 201 Mathematical Analysis III (3-0)3
[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 Mathematical Analysis IV (3-0)3
[MA 201]

Linear programming with graphs and ordinary algebra, vector algebra and matrix algebra used in linear programming, simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and applications of calculus in business operations.

MA 203 Calculus III (3-0)3
[MA 104]

Applications of integration including volumes, length of arc, curvature, work and center of gravity; determinants, scalar and vector products of three-dimensional vectors, partial differentiation, the solution of differential equations including linear, exact, homogeneous and nonhomogeneous; applications of differential equations.

MA 204 Calculus IV (3-0)3
[MA 203]

Applications of multiple integration including volumes, areas, center of gravity, and moment of inertia; polar coordinates, series including MacLaurin's and Taylor's; applications of series including series solutions of differential equations.

MA 221 **Linear Algebra** **(3-0)3**
[MA 104]

Mathematical induction, the properties of sets, mappings and mathematical logic; vectors in R^n, vector spaces, matrices, linear mappings, the effect of a change of basis, the matrix associated with a linear map; applications to geometry.

MA 222 **Linear Algebra** **(3-0)3**
[MA 221]

Scalar products and orthogonality, matrices and bilinear maps, polynomials and matrices, triangulation of matrices and linear maps, the Spectral Theorem, matrix analysis, applications to differential equations.

MA 301 **Advanced Calculus for Applications** **(3-0)3**
[MA 204]

Series solutions of ordinary differential equations, special functions, Laplace transformation, vector calculus, and matrices.

MA 302 **Advanced Calculus for Applications** **(3-0)3**
[MA 301]

Fourier series and integrals, boundary value problems and orthogonal functions, partial differential equations, partial differential equations, partial differential equations in engineering problems, and complex analysis.

MA 305 **Introduction to Real Analysis** **(3-0)3**
[MA 204]

Sets and functions, equivalence and countability, sets and sequences of real numbers, limits and metric spaces.

MA 306 **Introduction to Real Analysis** **(3-0)3**
[MA 305]

Continuous functions in metric spaces, connectedness, completeness, compactness, the Riemann integral, derivative, the Lebesgue integral.

MA 313 **Engineering Mathematics** **(4-0)4**
[MA 204]
[For students majoring in Electrical Engineering]

Vector analysis and complex variables with emphasis on applications in Electrical Engineering.

MA 321 **Modern Algebra** **(3-0)3**
[MA 222]

Elementary group theory, groups, cosets, normal subgroups, quotient groups, isomorphisms, homomorphisms, series of groups, the Sylow Theorems, free groups and homology groups.

MA 334 **Projective Geometry** **(3-0)3**
[MA 222]

Foundations of geometry, homogeneous coordinates, projective spaces, conics, linear transformations and surfaces.

MA 343 **Advanced Differential Equations** **(3-0)3**
[MA 204]

Formulation, solution and applications of linear and nonlinear ordinary differential equations, existence and uniqueness theorems, transform and numerical methods.

MA 344 **Advanced Differential Equations** **(3-0)3**
[MA 343]

Difference equations, boundary value problems, partial differential equations of mathematical physics.

MA 361 **Digital Computer Programming** **(2-0)2**
[MA 104]
[Offered both semesters]

An introduction to digital computer programming with concentration on the preparation of programs in the Fortran programming language. The Institute's computer will be used for processing of practice problems.

MA 362 **Numerical Analysis** **(3-0)3**
[MA 203]

Selected mathematical and numerical methods of solving engineering problems, especially those suitable for the Institute's IBM 1620; computer solutions of algebraic, transcendental, and ordinary differential equations.

MA 381 **Operations Research** **(3-0)3**
[MA 104 or MA 202]

The use of decision models in industrial systems. Quantitative approach to industrial alternatives. Fundamentals of probability and statistics, manufacturing and production models, time value of money, replacement analysis, statistical control, waiting line models, linear and dynamic programming, and theory of games.

MA 383 Statistical Methods (3-0)3
[MA 104]
[Offered both semesters]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 407 Introduction to Probability Theory (3-0)3
[MA 204]

Study of sample spaces, combinatorial analysis, probability distributions, random variables, central limit theorem.

MA 408 Introduction to Mathematical Statistics (3-0)3
[MA 407]

Treatment of data, measurements of dispersion, sampling, estimation, tests of hypotheses, regression theory and study of correlation.

MA 411 Complex Variables I (3-0)3
[MA 204]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals; Cauchy integral formula; power series and residues and poles.

MA 412 Complex Variables II (3-0)3
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 422 Topics in Algebra (3-0)3
[MA 321]

Elementary ring and field theory, quotient rings and ideals, homomorphisms or rings, rings of polynomials, algebraic extensions, automorphisms of fields, separal extensions, Galois Theory, introduction to categories and functions.

MA 431 Topology I (3-0)3
[MA 305]

Cardinality, partially ordered sets and Zorn's lemma, topology of the line and plane, topological spaces, continuity and topological equivalence.

MA 432 **Topology II** **(3-0)3**
[MA 431]

Metric and normed spaces, compactness, connectedness, product spaces, function spaces, fundamental group.

MA 434 **Matrix Algebra** **(3-0)3**
[MA 204]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 475 **Mathematical Logic** **(3-0)3**
[Senior Standing]

Propositional and statement logic. A rigorous development of the science of deductive logic with an emphasis on the nature of the logical structure underlying mathematical systems.

MA 497 **Foundations of Mathematics** **(3-0)3**
[Senior Standing]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 498 **Mathematics Seminar** **(3-0)3**
[Senior Standing]

Student reading, writing and criticism, topics from current literature, and review of some important elements of the undergraduate work.

MA 533 **Matrix Theory** **(3-0)3**
[MA 204]

Algebra of vectors, matrices, linear transformations and vectors, matrices and determinants, linear transformations and vector spaces, characteristic values and diagonal forms, calculus of matrices, matric polynomials, matric differential equations and applications.

MA 542 **Fourier Series and Boundary Value Problems** **(3-0)3**
[MA 204]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics and engineering, and boundary value problems.

MA 575 **Operational Mathematics** **(3-0)3**
[MA 204]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Applications in the analysis of vibrations, deflections, and electric circuits, problems in partial differential equations, and Fourier transforms.

MA 584 **Analysis of Random Processes** **(3-0)3**
[Permission of Instructor]

Axiomatic definition of Probability. Combined Experiments, Bernoulii Trials, Asymptotic Theorems, Bayes Theorem. The concepts of both discrete and continuous random variables, and functions of one or more random variables. The use of continuous probability density functions to describe both discrete and continuous phenomena. Expected value, moments, characteristic functions, mean square estimation. Sequences of continuous random variables, convergence concepts, law of large numbers, Central Limit Theorem.

MECHANICAL ENGINEERING

ME 104 **Design Graphics** **(1-0)1**

The design process, sketching; pictorial methods; conventional representation; graphs, diagrams; presentation of ideas.

ME 205 **Introduction to Mechanical Design** **(2-3)3**
[ME 104]

The drawing laboratory assignments develop the students "design vocabulary" and provide him with experience in sketching typical mechanical elements such as shafts, bearings, gears, cams, etc. Methods of developing design layouts, and assembly drawings are also covered. The machine shop laboratory acquaints the student with basic manufacturing operations such as turning, milling, drilling, etc. These aspects of the course are tied together in an assigned term design project.

ME 206 **Mechanical Engineering Laboratory I** **(3-0)1**
[ME 220; ME 242 Concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in mechanics of materials and thermodynamics.

ME 208 Introduction to Kinematics (3-0)3

A study of the basic principles of kinematics. Topics involved are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms. Available equipment serves as the basis of problems and assignments.

ME 211 Mechanics 1 (3-0)3
[MA 104; PH 101]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situations. The concept of stress and strain at a point. The stress-strain-temperature relations.

ME 212 Mechanics and Properties of Matter (4-0)4
[MA 204 concurrently]
[Primarily for EE students]

This course covers selected topics in Mechanics which are of fundamental importance to students majoring in Electrical Engineering. These include equilibrium of rigid and deformable solids, elastic moduli, kinematics, dynamics. Newton's laws, energy and momentum methods. Emphasis is given to colliding particles, central force systems, vibrating systems, and electrical analogues. Vector methods are stressed.

ME 215 Analytic Mechanics I (3-0)3
[MA 104; PH 101]
[Primarily for CN, PL, and TE students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Analytic Mechanics II (3-0)3
[ME 215]
[Primarily for CN, PL, and TE students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 Mechanics of Materials I (3-0)3
[MA 203; ME 211]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 242 Thermodynamics (3-0)3
[MA 203; PH 102]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability. Energy Conversion cycles.

ME 271 Machine Tool Laboratory (1-3)2
[Primarily for IM and PL students]

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, diecasting, welding, gears, and gearing.

ME 304 Materials Laboratory (0-3)1
[ME 220; ME 309]

Use of various testing equipment to establish material parameters used in structural analysis.

ME 307 Mechanical Engineering Laboratory II (0-3)1
[ME 309; ME 382; ME 395; all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, fluid mechanics and materials science.

ME 308 Mechanical Engineering Laboratory III (0-3)1
[ME 343; ME 354; both concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamic systems and heat transfer.

ME 309 Dynamics I (3-0)3
[MA 204; PH 102]

Kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The dy-

namics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. D'Alembert's principle. Impulse and momentum.

ME 315 Applied Mechanics (3-0)3
[MA 104; PH 101]
[Primarily for IM students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 Machine Design I (2-3)3
[ME 220; ME 309]

The principles of mechanics, and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 343 Heat Transfer (3-0)3
[ME 242; ME 382]

Mathematical theory and applications of steady and transient heat conduction in solids. Heat transfer in convection and application to heat exchangers. Hydrodynamic and thermal boundary layer theory. Development of thermal radiation theory and its application to heat exchange with and without absorbing gases. Combined heat transfer by conduction, and radiation.

ME 344 Heat and Power (3-0)3
[MA 104; PH 102]
[Primarily for IM students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 347 Elements of Thermodynamics and Heat Transfer (3-0)3
[MA 203; PH 102]
[Primarily for CE, EE, and TE students]

A study of the first and second law of thermodynamics with application to systems and changes of state. Heat transfer by

conduction, convection, and radiation. Steady and unsteady cases.

ME 354 Dynamic Systems (3-0)3
[MA 301; ME 309]

Unified approach to the modeling of simple mechanical, electrical, thermal and fluid systems. Transient and steady-state response of first and second order systems via classical and Laplace transform techniques. Supporting laboratory exercises emphasize real system behavior and associated physical measurement problems; error analysis.

ME 372 Strength of Materials (3-0)3
[ME 315]
[Primarily for IM students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 373 Plastics Mold and Die Design (2-2)3
[Primarily for PL students]

The fundamentals and basic principles of mold and die design for injection, compression, transfer, thermoforming and extrusion processes. Design considerations will include metal selection, runner and gate construction for the various polymeric materials. Laboratory will consist of actual design of a mold or die, with emphasis on relative drafting.

ME 376 Plastics Mold Design and Construction (0-3)1
[ME 271; ME 373]
[Primarily for PL students]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the machines in the Department of Plastics Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 **Fluid Mechanics I** **(3-0)3**
[MA 301 concurrently]

Development of basic fluid mechanical relations; continuity, momentum, and energy equations. Lagrangian vs. Eulerian approaches. Applications to inviscid and viscous, incompressible flows. Similarity and dimensional analysis. Boundary layer concepts and mathematical description. Fundamentals of turbulence. Introduction to low speed aerodynamics. Development of angular momentum princciples and their application to turbomachinery.

ME 384 **Fluid Mechanics** **(3-0)3**
[MA 204]
[Primarily for TE students]

Fluid statics; pressure and fluid forces, buoyant forces. Flow of "ideal' fluids. Equations of continuity and momentum. Potential flow. Dimensional analysis; π-theorem. Flow of "real" fluids; viscous effects, boundary layer, drag, pipe networks, open channel flow. Fluid measurements, and turbomachinery.

ME 395 **Materials Science** **(3-0)3**
[CH 002; PH 102]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 407 **Mechanical Engineering Laboratory IV** **(0-3)1**
[ME 413; ME 417; ME 497; all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, gas dynamics and automatic controls.

ME 413 **Gas Dynamics** **(3-0)3**
[MA 302; ME 242; ME 382]

Thermodynamics of gas mixtures and chemical equilibrium. Extension of basic equations of motion and energy to inviscid, compressible flows. Acoustic equations. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Crocco's theorem. Prandtl-Meyer expansion. Method of characteristics. Linearized flow theory.

ME 417 Dynamics II (3-0)3
[MA 302; ME 309]

Work-energy relation. Conservative force fields. Impulse and Momentum. Conservation of energy. Generalized coordinates and Lagrange's Equations. Vibrations of single and multiple degree of freedom systems.

ME 419 Nondestructive Evaluation Techniques (3-0)3
[Senior Standing]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical, and metallurgical properties. May be taken for Graduate Credit.

ME 421 Machine Design (2-3)3
[ME 216]
[Primarily for TE students]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered.

ME 422 Machine Design II (2-3)3
[ME 320]

A continuation of ME 320. Laboratory problems emphasize aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria. May be taken for Graduate Credit.

ME 428 Kinematic Mechanism Synthesis (3-0)3
[ME 309]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis. May be taken for Graduate Credit.

ME 452 **Applications of Numerical Analysis** **(3-0)3**
[Senior Standing]

Iterative solutions of transcendental equations. Rapidity of convergence and estimate of error. Method of least squares. Extrapolation to the limit. Numerical differentiation. Numerical and Gaussian quadrature. Romberg integration. Numerical solution of first order, ordinary differential equations. Predictor and corrector formulas. Finite difference solutions of second order, partial differential equations. Applications to problems in fluid mechanics, solid mechanics, and heat transfer. Solutions set up and carried out on digital computer. May be taken for Graduate Credit.

ME 453 **Senior Project I** **(0-3)1**
[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members. The first term is devoted to problem definition, solution synthesis and design analysis.

ME 454 **Senior Projects II** **(0-6)2**
[Senior Standing]

A continuation of ME 453. The second term is devoted to trade off and optimization, construction, testing, evaluation and reporting.

ME 462 **Engineering Analysis** **(3-0)3**
[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Problem examples include both discrete and continuous systems encountered in the fields of solid mechanics, fluid mechanics, heat transfer, and electrical networks. May be taken for Graduate Credit.

ME 468 **Fluid Machinery** **(3-0)3**
[ME 413]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-dimensional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation. May be taken for Graduate Credit.

ME 472 Experimental Stress Analysis (2-3)3
[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distributions by experimental methods. Photoelasticity, birefringent coatings, brittle coating, analogies, strain gage applications, rosette analysis. May be taken for Graduate Credit.

ME 473 Mechanics of Materials II (3-0)3
[MA 302; ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center; unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections. May be taken for Graduate Credit.

ME 475 Physical Metallurgy (3-0)3
[ME 395]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phenomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture. May be taken for Graduate Credit.

ME 448 Environmental Conditioning (3-0)3
[ME 242 or ME 347]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces. May be taken for Graduate Credit.

ME 493 Industrial Instrumentation (2-0)2
[MA 104; PH 102]
[Primarily for PL students]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 497 Automatic Control Systems (3-0)3
[EE 212; MA 302; ME 354]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 530 Ultrasound, A Nondestructive Evaluation Method (2-3)3
[MA 302]

Propagation characteristics of ultrasound are developed and analyzed to indicate usefulness as a nondestructive method of evaluation. Equipment for generation detection and display. Scientific and engineering applications using velocity and attenuation measurements are stressed.

ME 531 Advanced Thermodynamics (3-0)3
[ME 242]

A comprehensive treatment of the first and second law. Criteria of equilibrium, Multicomponent systems. Chemical reactions and chemical equilibrium, Maxwell relations, availability. Applications to selected topics.

ME 534 Transport Processes (3-0)3
[ME 343; MA 302]

Diffusive and convective transport of mass, momentum and energy. Free and forced convection in laminar and turbulent flows. High velocity flows, ablation, boiling and condensation.

ME 535 Advanced Heat Transfer (3-0)3
[ME 343; MA 302]

Conduction in steady and transient state problems. Solution by formal mathematics, numerical, graphical and analogy method. Thermal stresses. Basic laws of radiation; heat transfer between surfaces, absorbing media.

ME 541 Advanced Fluid Mechanics (3-0)3
[ME 382; MA 302]

Basic equations of motion of inviscid fluid. Irrotational flows, stream function and velocity potential. Complex potential, conformal transformations, streaming motions, sources and sinks. Vertical flow.

ME 542 **Advanced Gas Dynamics** **(3-0)3**
[ME 382; MA 302]

Equations of motion for inviscid, compressible fluid. One-dimensional steady flow with area change, friction, heat transfer and combustion. Shock waves. Unsteady flows and wave phenomena. Similarity, characteristics, small disturbances, approximation procedures.

ME 546 **Energy Conversion** **(3-0)3**
[EE 212; MA 302; ME 343]

Concepts of thermodynamics pertaining to energy conversion, irreversible thermodynamics. Solid-state phenomena involved in conversion processes; energy forms, equations of states, and energy fields. Selected topics in direct energy conversion systems.

ME 552 **Continuum Mechanics** **(3-0)3**
[ME 220; ME 242; MA 301]

Stress and deformation in a continuum in tensor notation. Fundamental laws of mechanics and thermodynamics. Applications to elastic, viscous and viscoelastic substances.

ME 554 **Theory of Elasticity** **(3-0)3**
[ME 473; ME 552]

Formulation of the problem of elastic equilibrium. Torsion and flexure of prismatic bars, contact stresses, plane stress, plain strain and stress concentrations.

ME 556 **Theory of Inelastic Continuum** **(3-0)3**
[ME 473; ME 552]

Development of the constitutive equations governing inelastic (anelastic, viscoelastic, plastic and visco-plastic) deformations. Theorems and boundary valve problems as applied to inelastic continua.

ME 561 **Advanced Dynamics** **(3-0)3**
[ME 417]

Dynamics of mechanical systems by use of direct and variational methods. Three-dimensional rigid body dynamics, and vibrations of lumped parameter and continuous systems. Nonlinear and self-excited oscillations. Stability.

ME 564 **Structural Dynamics** **(3-0)3**
[ME 417]

Response of complex structures to deterministic and random excitations. Exact and approximate normal modes by energy, and by differential and integral methods. Proportional and non-proportional damping.

METEOROLOGY

MY 205 **Elementary Meteorology** **(3-0)3**
[MA 104; PH 102]

Instantaneous and average distributions of pressure, temperature, water vapor, and velocity. Characteristic features of these distributions; waves, cyclones, anticyclones and fronts. Distribution of fog, clouds, precipitation, thunderstorms & tornadoes. Meteorological instruments & observations.

MY 206 **Elementary Meteorology** **(3-0)3**
[MY 205]

Heat balance & qualitative circulation theory. Elements of atmospheric thermodynamics & hydrodynamics: equation of state; first law of thermodynamics; hydrostatic equilibrium & its stability; the laws of large-scale motion; gradient, geostrophic & thermal winds.

MY 301 **Atmospheric Dynamics** **(3-0)3**
[MY 206]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium & its stability. Convection theory. The equations governing large-scale frictionless motion in the atmosphere. Steady state motion.

MY 302 **Atmospheric Dynamics** **(3-0)3**
[MY 301]

Unsteady motion: development of thermal circulations: barotropic & baroclinic conditions, circulation, vorticity & divergence; mechanism of pressure change; Sutcliffe development and elements of numerical weather prediction.

MY 307 **Tropical Meteorology** **(3-0)3**
[MY 206]

An introduction to tropical meteorology. Distribution of temperature, pressure, water vapor and velocity. Observations

from aircraft, satellites and radar. Analysis of tropical data. Air sea interaction; convection and clouds. The trade wind region and intertropical convergence zone. Easterly waves and tropical storms.

MY 308 Synoptic Meteorology (2-3)3
[MY 206]

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network.

MY 403 Physical Meteorology (3-0)3
[MY 302]

Solar and terrestrial radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; radiative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion.

MY 413 Oceanography (3-0)3
[MY 302]

Physical properties of sea water. Distribution of pressure, temperature & salinity. Heat budget. Theories of wind-driven and thermal circulations. Transfer processes. Waves & tides. General circulation theory.

MY 415 Advanced Atmospheric Dynamics (3-0)3
[MY 302]

Perturbation theory of atmospheric wave motion. Numerical weather prediction techniques and models. Viscosity, turbulence and energy dissipation.

MY 416 Advanced Atmospheric Dynamics (3-0)3
[MY 415]

Diffusion in the atmosphere & meteorological aspects of air pollution. Stability of atmospheric circulations. General circulation theory & models.

MY 421 Analysis and Forecasting (1-6)3
[MY 302; MY 308]

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical

motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting.

MY 422 Analysis and Forecasting (1-6)3
[MY 421]

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures.

NUCLEAR ENGINEERING

NU 201 Introduction to Nuclear Engineering (3-0)3

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission.

NU 202 Introduction to Nuclear Engineering (3-0)3

Utilization of nuclear energy. Nuclear Reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 305 Nuclear Instrumentation (2-4)4

The lectures are devoted to the design and operating characteristics of nuclear detectors and their use with electrometers, ratemeters, scalers, and pulse height analysers. The laboratory work is devoted to the characteristics of detectors and associated measuring circuits.

NU 306 Nuclear Instrumentation (2-4)4

The lectures cover the fundamentals of circuit theory as applied to pulse circuits. The laboratory work is a continuation of the laboratory experiments of NU 305.

NU 405 Nuclear Reactor Engineering (3-0)3

Neutrons, cross-sections and fission. Steady state and the criticality condition. Reflected, homogeneous and heterogeneous reactors. Fast reactors.

NU 406 Nuclear Reactor Engineering (3-0)3

Reactor control. Kinetics and reactivity effects. Control systems and instruments. Coolants and moderators. Fuels. Reactor operations.

NU 493 Advanced Nuclear Laboratory (0-6)3

Characteristics of tubes and transistors. Construction and operating characteristics of amplifiers and oscillators. Principles of feedback and servo system. Construction of pulse and digital circuits; binary circuits, mono and astable; trigger, coincidence and anti coincidence circuits.

NU 494 Advanced Nuclear Laboratory (0-6)3

Neutron activation experiments. Szilard Chalmer experiment. Measurements of slowing down lengths, diffusion lengths. Fermi Age. Effect of poisons in moderators as well as insertion of control rods. Experiments on reactor simulator including period measurements and effects of poison. Experiments on accelerator and reactor.

NU 495 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

NU 496 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Continuation of NU 495 for a second semester.

NU 505 Reactor Physics (3-0)3

Nuclear Reactions induced by neutrons: cross sections, fission; diffusion and slowing down of neutrons; Diffusion, Fermi Age and multi group treatment of unreflected and reflected homogeneous reactors, reactor design parameters.

NU 506 Reactor Physics (3-0)3

Reactor physics problems relating to the operation and kinetics of a nuclear reactor. Effect of poisoning, and temperature on design criteria; excess reactivity; elementary reactor kinetics, perturbation theory and control rod theory. Introduction to transport theory.

NU 507 Reactor Engineering (3-0)3

Analysis of fluid dynamics, heat transfer and thermal stresses as they influence the performance of a nuclear power reactor.

NU 508 Reactor Engineering (3-0)3

Relations of consideration of NU 507 to cover physics design of a reactor. Power Plant. Thermodynamics; energy production and distribution.

PAPER ENGINEERING

PA 301 Engineering Analysis of Pulp Systems (3-0)3
[CN 204, PA 307 taken concurrently]

Lectures and problems concerned with the engineering design and technology of pulp manufacturing by commercial processes. Discussion of bleaching chemistry and the use of secondary fibers.

PA 302 Engineering Analysis of Paper Systems (3-3)4
[PA 301, PA 307]

Discussion and study of engineering, design and economics of commercial methods of production of papers. Stock preparation; changes in physical and chemical properties of pulps; filling and loading of fibers; sizing, coloring and other additives. Material and energy relationships of various processes. Laboratory projects designed to illustrate principles expounded in lectures.

PA 307 Physical Testing and Data Analysis (2-3)3
[Approval of Instructor]

Fundamentals of the mechanical and optical testing of paper and allied products. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of testing. Structure of materials revealed by physical tests. Laboratory projects designed to illustrate problems involved in processing of pulp and evaluation of paper.

PA 403 Engineering Analysis of Converting (3-0)3
[PA 302]

Lectures and problems concerned with the engineering design, technology and economics of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials used for coatings. Mechanical, coating, impregnating, laminating and printing processes discussed in detail.

PA 405 Paper Converting Laboratory I (0-3)1
[PA 403 taken concurrently]

Development of converting techniques used with paper and paperboard. Use of Tappi Methods of evaluation. Emphasis is placed on colloidal and rheological properties of materials used in coating. Detailed written and oral reports.

PA 406 Pulp and Paper Systems Calculations (2-0)2
[PA 302, PA 307]

Mathematical analysis of various processes encountered in the pulp and paper industry, using material and energy balances. Application of chemical engineering principles applied to various operations. May be taken for graduate credit.

PA 408 Paper Converting Laboratory II (0-3)1
[PA 405]

Special converting problems are studied in detail. Use of more specialized testing methods to evaluation coatings and other paper and paperboard converted products. Special emphasis is placed on the preparation of special converted products and the testing thereof. Oral and written reports required.

PA 410 Analysis of Paper Formation Process (2-0)2
[PA 302]

Discussion of the variables and factors involved in the formation of the paper web. Consideration given to fiber flocculation and orientation and to headbox design. May be taken for graduate credit.

PA 419 Special Senior Projects Credits to be arranged

Original research projects primarily in the field of paper engineering, supervised by a staff member. Reports required on work done.

PA 503-504 Advanced Converting Processes (3-0) (3-0)6
[PA 403, PA 408]

Specific converting processes. Analysis of coating processes (water- and solvent-based), extrusion coatings and hot metal coating. Latest techniques used by the converting industry, involving mechanical and chemical operations. Engineering analysis of processes. Oral and written reports and plant visits.

PA 505 Physics of Paper (3-0)3
[Approval of Instructor]

Structures of fibers from a fundamental viewpoint and their effect on strength and other properties of sheets made from these fibers. Comparison of cellulosic and synthetic fibers. Engineering properties of fiber materials.

PA 506 New Techniques in the Paper Industry (3-0)3
[Approval of Instructor]

Lectures and discussion of new developments in engineering, design and application of physical and chemical principles in the manufacture of paper and paper products. Economic comparisons of new processes. Plant visits. Oral and written reports.

PA 507 Fundamentals of Reprography (2-0)2
[Approval of Instructor]

An in-depth study of replicating and imaging systems from carbon paper, to xerography, to halography, covering theory and principles of operation, design and development of hardware and supplies, typical specifications and a cursory economic evaluation of these systems. Because of the unique technical character of this new field, a review of copyright, patents and trade secrets is provided. The current state of the art is reviewed and this potential represented by recent developments in the field is examined.

PA 509 Economics of the Paper Industry (2-0)2
[Approval of Instructor]

An evaluation of the paper industry from an economic viewpoint. Examination of costs and availability of different raw materials, additives and finishing materials. Analysis of competitive position of the paper industry and its products. Evaluation of foreign competition.

PA 512 Advanced Fiber Processing (3-0)3
[PA 302]

A study of fiber properties as related to fiber processing. Treatment of various theories of fiber processing. Discussion of mechanical treatments of fibers on the wet and dry properties of papers made from these fibers.

PHYSICS

PH 101 Physics (4-1)4

Mechanics: kinetics; dynamics — inertia, mass, momentum, force, impulse, application of Newton's laws, inertial and noninertial frames of reference.

PH 102 Physics (4-2)4
[PH 101 or equivalent]

Work, energy, rotational kinematics and dynamics, angular momentum, gravitation, elasticity, and simple harmonic motion. Temperature, ideal Gases, kinetic theory, thermal properties of solids and liquids, 1 and 2nd law of thermodynamics, Carnot cycle, entropy.

PH 201 Physics (4-2)4
[PH 102]

Elements of Electricity: electrostatics, fields, flux, Coulomb's law, electric potential, Ampere's Law, Faraday's Law and applications. Development of the lumped parameter circuit. Displacement current. Geometrical Optics.

PH 202 Physics (4-2)4
[PH 201]

Acoustical and optical wave phenomena, such as beats, Doppler Effect, reflection, refraction, interference, and diffraction; polarization; and spectra. Introduction to modern physics, atomic view of matter, Bohr theory of the atom, wave-particle duality.

PH 207 Mathematical Techniques of Physics I (4-0)4
[MA 104]

Techniques of approximate solutions of physical problems. Techniques of exact solutions of physical problems with applications to electrostatics, magnetostatics, and hydrodynamics, with appropriate mathematical background.

PH 208 Mathematical Techniques of Physics II (4-0)4
[PH 207]

Techniques of solutions of differential equations used in physics and engineering problems; in particular solution of the wave equation in bounded and unbounded media, with applications to electromagnetic phenomena and propagation of heat and sound.

PH 211 | **Physics** | **(3-0)3**

[PH 102]

[For physics majors only]

Same basic curriculum as in PH 201 with greater emphasis on field theory aspects. In addition, development of Maxwell's equations in integral differential form. Simple solutions and applications.

PH 212 | **Physics** | **(3-0)3**

[PH 211]

[For physics majors only]

Acoustical and optical Wave phenomena; reflection, refraction, interference, diffraction, polarization, Doppler Effect: group velocity Fourier analysis. Introduction to special theory of relativity; an atomic view of matter. Breakdown of classical mechanics.

PH 293 | **Experimental Physics** | **(2-6)4**

[Permission of Instructor]

Physical phenomena and methods used to observe and measure them. Elements of Circuit theory required for an understanding of measurements made with AC and DC instruments. Difficulties, limitations and interpretation of measurements. Demonstration of pertinent physical phenomena.

PH 294 | **Experimental Physics** | **(2-6)4**

[Permission of Instructor]

Continuation of PH 293 for the second semester.

PH 311 | **Intermediate Mechanics** | **(3-0)3**

[PH 208]

Kinematics of a single particle, and analysis of Newton's laws of motion, the mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, central forces, the mechanics of systems of particles from the points of view of Newton, Lagrange, and Hamilton.

PH 312 | **Intermediate Algebra** | **(3-0)3**

[PH 208]

Generalized coordinates and moments, the Hamiltonian function, rotating rigid bodies, moments and products of inertia, principal axes, the theory of small oscillations, normal modes of vibration, and the vibrating string.

PH 335 Modern Physics (3-0)3
[PH 208; PH 212]

Black body radiation, Rayleigh, Jean's Law, Planck's law, photoelectric effect, X-rays, Compton effect, wave particle duality, DeBroglie waves, wave pockets, atomic structure, Rutherford model and Rutherford scattering. Bohr Model, Franck-Hertz experiments, correspondence principle, Bohr-Sommerfield model. Introduction to Wave Mechanics and quantum numbers. Pauli exclusion principle, and vector model of the atom.

PH 336 Modern Physics (3-0)3
[PH 335]

Elementary application of wave and quantum mechanics to natural phenomena. Electron spin, spectroscopic nomenclature. Zeeman effect. Stern Gerlach experiment. Applications to solid state and introduction to nuclear physics.

PH 353 Electromagnetic Theory (3-0)3
[PH 208; PH 211]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity.

PH 354 Electromagnetic Theory (3-0)3
[PH 353]

Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 363 Introductory Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 366 Intermediate Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neuton physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 393 — Advanced Laboratory — (0-6)2
[Permission of Instructor]

A laboratory course which accompanies the junior and senior courses in the department, and which may serve as a vehicle for undergraduate experimental research in selected fields of physics and for practice in exposition or in teaching.

PH 394 — Advanced Laboratory — (0-6)2
[Permission of Instructor]

Continuation of PH 393 for a second semester.

PH 423 — Thermodynamics — (3-0)3
[PH 208]

A macroscopic analysis of the behavior of thermodynamic systems including the following topics: thermodynamic equilibrium states, the concept of temperature, the first law of thermodynamics, real and ideal gases, the ideal gas temperature scale, heat engines and refrigerators, the second law of thermodynamics, reversible processes, the Carnot cycle, the Kelvin temperature scale, the concept of entropy and its philosophical significance, pure substances, enthalpy, Helmholtz free energy, Gibbs free energy, Maxwell's relations, the TdS equations, and applications found in modern physics.

PH 424 — Introduction to Statistical Mechanics — (3-0)3
[PH 441; PH 423]

A continuance of PH 423, but a microscopic level and including the following topics: probability theory, the classical statistical mechanics of Gibbs, phase space, phase density, Liouville's theorem, the microcanonical, canonical, and grand canonical ensembles, the partition function, the statistical mechanical interpretation of the thermodynamic functions and laws, modifications required by quantum mechanics, the Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution laws, and applications of the theory to ideal gases.

PH 441 — Introduction to Relativity and Quantum Mechanics — (3-0)3
[PH 336; PH 312; PH 354]

Coverance of physical laws, Lorentz transformation, relativistic mechanics, tensor analysis, proper time, Minkowski force, particle collisions, relativistic electrodynamics, field tensor. Experimental basis for interference of particles and the un-

certainty principle; postulates of quantum mechanics, operators hermiticity, commutativity, orthogonality of eigenfunctions.

PH 442 Introduction to Relativity and Quantum Mechanics (3-0)3
[PH 336; PH 312; PH 354]

First order perturbations of energy levels, harmonic oscillator, free particle, one electron atom, hydrogen fine structure, Pauli principle and atomic shell structure.

PH 461 Nuclear Physics (3-0)3
[PH 336]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay.

PH 462 Nuclear Physics (3-0)3
[PH 461]

Alpha decay theory, gamma emission, two nucleon systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471 Solid-State Physics (3-0)3
[PH 441]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption.

PH 472 Solid-State Physics (3-0)3
[PH 471]

Lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semi conductor crystals.

PH 495 Special Research Problems (3-0)3
[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 496 Special Research Problems (3-0)3
[Permission of Head of Department and Instructor]

Continuation of PH 495 for a second semester.

PH 505 — Mathematical Methods of Physics — (3-0)3

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differential equations and their classifications.

PH 506 — Mathematical Methods of Physics — (3-0)3

[PH 505]

Boundary value problems, Sturm Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

PH 507 — High-Energy Physics — (3-0)3

[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511 — Classical Mechanics — (3-0)3

[PH 312]

An analysis of the mechanics of systems of particles from the points of view principally of Newton, Lagrange, and Hamilton, including the following topics: Newton's laws, conservative and non-conservative forces, holonomic and nonholonomic constraints, Lagrange's equations, Hamilton's principle, orthogonal transformations, the motion of rigid bodies, rotating frames of reference, the rotation of a symmetrical rigid body.

PH 512 — Classical Mechanics — (3-0)3

[PH 511]

Hamilton equations, the principle of least action, canonical transformation, Poisson brackets, Hamilton-Jacobi theory, action and angle variables, and a comparison between classical mechanics and geometrical optics.

PH 515 — Quantum Mechanics — (3-0)3

[PH 441; PH 511 taken concurrently]

Wave pockets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum.

PH 516 Quantum Mechanics (3-0)3
[PH 515]

Spin, time-dependent and independent peturbation theory. Scattering theory.

PH 517 Advanced Quantum Mechanics (3-0)3

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory.

PH 518 Advanced Quantum Mechanics (3-0)3
[PH 517]

Second quantization and canonical commutation rules. Connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 521 Statistical Mechanics (3-0)3
[PH 424]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein.

PH 522 Statistical Mechanics (3-0)3
[PH 521]

Applications of statistical mechanical methods to thermodynamics, solid state physics, and nuclear physics.

PH 557 Electricity and Magnetism (3-0)3
[PH 208; PH 354]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity.

PH 558 Electricity and Magnetism (3-0)3
[PH 557]

Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561 Nuclear Physics (3-0)3
[PH 462]

Stationary states of nuclei nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles.

PH 562 **Nuclear Physics** **(3-0)3**
[PH 561]

Gamma rays and neutrons; nuclear forces and nuclear models; fast neutron physics.

PH 573 **Quantum Theory of Solids** **(3-0)3**
[Permission of Instructor]

Acoustic and optical phonons; plasmons; the Hartree-Fock approximation; many-body theory; electron-phonon interactions; the band theory of solids.

PH 574 **Quantum Theory of Solids** **(3-0)3**
[Permission of Instructor]

Metals; semiconductors; transport theory; neutron diffraction; superconductivity; magnetism, and magnetic resonances.

PH 575 **Neutral Particle Transport** **(3-0)3**

Boltzmann and integral transport equations, Spherical Harmonic, and variational methods. Correction to diffusion theory.

PH 576 **Neutral Particle Transport** **(3-0)3**
[PH 575]

Special methods and solving transport equations. Adjoint functions. Applications to physical systems.

PH 583 **General Theory of Relativity** **(3-0)3**
[Prerequisite: Knowledge of Special Relativity]

Review of Newtonian gravitational theory and special relativity. Weak and strong principles of equivalence. Tensor analysis in Riemann spaces. Einstein's equations for the gravitational field.

PH 584 **General Theory of Relativity** **(3-0)3**
[Prerequisite: Knowledge of Special Relativity]

Classic tests of Einstein's theory; spherically symmetric solutions. Gravitational field theory, and the canonical analysis of general relativity.

PH 593 **Graduate Laboratory** **Credits to be arranged**
[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 594 **Graduate Laboratory** **Credits to be arranged**
[Permission of Instructor]

Continuation of PH 593 for a second semester.

PH 942 **Physics** **(3-2)4**
[46.22]

Elements of electricity and magnetism: Coulomb's law, fields, Gauss' law, potential, current, dc circuits, magnetic fields and forçes, induced emf, ac circuits.

PLASTICS TECHNOLOGY

PL 201 **Introduction to Polymeric Materials** **(2-0)2**

A descriptive subject to acquaint the student with plastics as a class of materials. The history, classification, definitions, raw materials, methods of manufacture, properties and uses of polymeric materials.

PL 202 **Introduction to Polymeric Materials** **(2-0)2**
[PL 201 or Permission of Instructor]

A continuation of PL 201. Emphasis is placed on the engineering thermoplastics. Polymers for thermal extremes are also discussed.

PL 301 **Plastics Technology I** **(2-2)3**
[PL 201, PL 202 or Permission of Instructor]

Analysis of additives including stabilizers, plasticizers, biocides, release agents, flame retardants, colorants and foaming agents as well as modifiers, fillers and reinforcing agents. Laboratory instruction in the processing and fabrication of plastics materials.

PL 302 **Plastics Technology II** **(2-2)3**
[PL 301 or Permission of Instructor]

Discussion of compounding techniques and the evaluation and development of typical plastics molding compounds. Survey of materials for reinforced plastics and composites, film and sheeting, adhesives, and non-plastics applications of polymers. Continued laboratory instruction in the processing and fabrication of plastics materials.

PL 401 Plastics Technology III (2-2)3

A theoretical and practical study of plastics process engineering. Correlation of composition, processing and fabrication with hold, product and equipment design. Assignment of senior research projects designed to develop the student's ability to organize and conduct investigations of materials performance and processing techniques.

PL 402 Plastics Technology IV (2-2)3

A continuation of PL 401

PL 403 Physical Properties of Polymers (2-2)3
[Open to Seniors only]

Introduction to basic mechanical properties of polymers as linear viscoelastic materials. Concepts of creep, stress relaxation, and superposition principles emphasized. Important material parameters are obtained in laboratory sessions.

PL 404 Physical Properties of Polymers (2-2)3
[PL 403]

Dynamic mechanical behavior, interrelations between various properties, electrical behavior, miscellaneous mechanical properties, optical properties.

PL 406 Polymer Structure (3-0)3

The fundamental relationships between molecular structure, properties and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical composition, molecular size and flexibility, intermolecular order and bonding, and supermolecular structure. Properties include processability; mechanical, acoustic, thermal, electrical, optical, and chemical properties; price, and balance of properties. Applications include rigid solids, flexible solids, foams, films, and non-plastics applications.

PL 407 Plastics Industry Organization (3-0)3

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit, and growth.

PL 409 Senior Research in Plastics (1-6)3

Individual research projects in plastics chemistry, properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs, and submit final reports for publication.

PL 410 Senior Research in Plastics (1-6)3

Continuation of PL 409

PL 411 Plastics Seminar (1-0)1

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

PL 412 Plastics Seminar (1-0)1

A continuation of PL 411

RADIOLOGICAL SCIENCES

RS 100 Basic Radiolgical Health Physics 8 weeks
[Primarily for RS students]

Introduction to atomic and nuclear physics; natural and artificial radioactivity, radiation, decay schemes; nuclear reactions including fisson and fusion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations; principles of radiation detection and detection devices; counting systems and assay of α, β, γ emitters; survey and monitoring equipment; external radiation exposure and protection techniques; internal radiation exposure and protection techniques; radiation safety and control.

RS 200 Reactor and Accelerator Radiation Safety and Hazards Evaluation 3 weeks lecture 1 week applied work experience
[Primarily for RS students]

I. Reactors: Principles of reactor operation and control; instrumentation and safety systems; radioactivity and radiation sources; shielding; radiation survey and monitoring equipment; personnel monitoring and radiation exposure control; liquid and gaseous effluent — types and quantities, analyses, monitoring; site selection; containment; meteorology and environmental monitoring programs; waste management; fuel reprocessing; licensing and regulations.

II. Accelerators: Principles of operation and types of particle accelerators; dependence of radiation output on mode of operation including beam current and beam alignment, high voltage, type of particle projectile and type of target material; shielding; radiation survey and monitoring equipment; radiation safety systems and procedures; personnel monitoring and radiation exposure control.

RS 210 Medical Radiation Physics and X-Ray Protection **3 weeks lecture 1 week applied work experience**
[Primarily for RS students]

I. Sealed Sources and Radioisotopes: Therapeutic and diagnostic uses of radioisotopes and sealed sources; dose calculations; sealed source teletherapy units; radiation shielding; radiation survey and monitoring equipment; reduction of unnecessary radiation exposure.

II. X-Ray: X-ray circuits and components; production and properties of X-rays; diagnostic and therapeutic applications; clinical radiological procedures; reduction of exposure to patients and medical personnel; dental X-ray protection; X-ray shielding design; radiation survey and monitoring equipment; procedure for inspection and survey of X-ray installation; physical properties and use of high speed radiographic film; radiation protection guides.

RS 300 Applied Radiological Health Physics **10 weeks work experience**
[Primarily for RS students]

Ten weeks of applied work work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 401 Principles of Radiation Safety and Control **(3-0)3**
[PH 363 or equivalent]

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material.

RS 411-412 Research in Radiological Sciences **8**
[Primarily for RS students]

A research problem related to the field of radiation protection is investigated by the student under the direction of faculty

and staff of the Nuclear Center. The student will present a seminar on his research project. Areas of research anticipated include radiation shielding, radiation detection and measurement, radiation survey and monitoring, radiation biology, radiation chemistry, radiobiology, radiochemistry, radioecology, natural radioactivity, fall out, analyses and measurement of radioactivity and radiation levels associated with the operation of reactors and accelerators, and radioactive aerosols.

RS 422 Environmental Radiation and Nuclear Site Criteria (3-0)3
[Permission of Instructor]

Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, aquatic and terrestrial ecosystems; design and operation of environmental surveillance programs around nuclear facilities; reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations.

RS 431-432 Seminar in Radiological Sciences (2-0) (2-0)2
[Primarily for RS students]

Guest speakers and staff of the Nuclear Center present not only topics of current interest to the field of radiation protection but also descriptions of radiological health physics programs at various nuclear and radiation facilities. Students present a seminar either on their research project or on their critical essay.

RS 441 Radioisotope Techniques (3-3)4

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Integrated into both laboratory and lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities.

RS 451 Introduction to Electronic Product Radiation (3-0)3
[Permission of Instructor]

The theoretical and applied aspects of the generation, measurement, and uses of radiant energy from electronic products whose emissions span the entire electromagnetic spectrum; ultrasonic energy emitted by electronic products; biological effects, standards of protection and control, and consequences and intent of Public Law 90-602.

RS 452 Electronic Product Radiation Laboratory (1-4)3
[RS 451]

A laboratory course aimed at practically demonstrating some of the more important principles and instrumentation used in the generation and measurement of electronic product radiation. Experiments involving the properties and measurement of radiation from lasers and microwave sources will represent a large portion of the course.

RS 501 Radiation Physics and Shielding Design (3-0)3
[Permission of Instructor]

Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding of point, surface, and volume sources; shielding design factors in reactor and accelerator operation.

RS 503 Introduction to Radiation Chemistry (3-0)3

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination.

SOCIAL SCIENCES

SS 223 The United States: 1865-1912 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

SS 224 The United States: 1912 to the Present (3-0)3
[No prerequisite, but SS 223 is recommended as background]

Continuing the topical analysis of SS 223, a study will be made of the political philosophies from Wilson to Johnson, the industrial problems of the 20th Century, the transition from isolation to free world leadership, economic cycles, the impact of science, and current issues.

Collateral readings will be required for each topic.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 226 Europe: 1914 to the Present (3-0)3

A study of the period of the two World Wars and the post-war periods in which totalitarianism, new power alignments, and new international organizations developed.

SS 235 England: Roman Times to the Restoration (3-0)3

The history of England to 1660 with emphasis on the development of the institutions of monarchy and Parliament, culminating in the clash between the two and the Restoration in 1660.

SS 236 England: The Restoration to the Present (3-0)3

England's history from the Restoration, tracing the rise of parliamentary government, the cabinet system, domestic reforms, and imperial policy.

SS 301 Government of the United States (3-0)3

A study of the political structure of the national government and the most crucial problems, domestic and foreign, that it is facing today. Emphasis is given to the manner in which the American federal government is confronting these problems and their influence on American society.

SS 302 Conduct and Control of Foreign Policy (3-0)3

Consideration of the ways in which a state's conduct of its foreign policy affects and is affected by both the substance and the processes of its domestic politics. Primary consideration is given to the United States and the principal nations of Western Europe.

SS 303 Psychology (3-0)3

An introduction to the basic principles of human behavior. The major areas covered include the origins and development of psychology as a science, the stages of human development, motivation and emotion, sensing and perceiving, the nature and management of learning, testing ability and intelligence, and neuroses and psychoses.

SS 305 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 307 Seminar in Sociology (3-0)3

[Limited to upperclassmen. Approval of Instructor required.]

Designed to assist the advanced student with the proper sociological concepts and insights as they apply to the social settings in busines and industry. The core objective is the development — through the case method — of the balance between skill and knowledge and their application in sound technical and administrative decisions affecting individuals and groups within organizations.

SS 371 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in the United States. Emphasis is given to the economic, political, and social which were causing the simultaneous growth of the sectionalism that led to the Civil War.

SS 403 Psychological Warfare (3-0)3

Inquiry into the role of psychological warfare in modern foreign policy. Special attention is given to such activities as economic aid, technical assistance, military missions, cultural exchanges, and information services of various types.

SS 451 History of France (3-0)3

The history of the development of ideas and institutions in modern France from the age of absolutism through the mid-twentieth century.

SS 459 World Politics: The Central Problem of War (3-0)3

War as the central phenomenon of world politics — Its causes and functions in theory and in history; its effects on the individual and society; efforts to control it; and the ethical problems that it raises.

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles have been applied by the United States are examined through case studies.

SS 472 Defense Policy (3-0)3

A study of the relationship of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of national security.

SS 477 Russia: The Empire (3-0)3

A study of the history of the Empire of the Tsars with special emphasis upon the economic, political, and social problems that led to the Revolution of 1917.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U. S. S. R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviety state; the Stalinist period; and current domestic and foreign problems.

SS 479 The Far East Since 1842 (3-0)3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to the study of the development of mainland and island states. Emphasis is given to American and European interest, policies, and relationships with China, Japan, and Korea.

SS 480 Modern China: 1644 to the Present (3-0)3

A study of developments in China's economic, political, and social evolution from the Manchu conquest to the Maoism of the 1960's. Emphasis will be given to China's foreign relations under the Manchus, during the "Nationalist" period, and since the advent of the Communist regime in 1949, as well as to "Red China's" role in Asian and global affairs today.

SS 481 The Greeks and Western Civilization (3-0)3

An examination of the contributions of the Greeks to our culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

SS 482 The United States: Urban History (3-0)3

Social, cultural, economic, and political factors in the formation and development of the modern American city.

SS 483 The Development of Western Civilization: To 1789 (3-0)3

The history of the development of ideas and institutions from democratic Athens to the absolutism of Louis XIV.

SS 484 The Development of Western Civilization: Since 1789 (3-0)3

The development of ideas and institutions from the age of absolutism to the mid-twentieth century.

SS 485 Modern Governments of Europe (3-0)3

A study of the institutions and politics of the United Kingdom, France, Germany, and the Soviet Union.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 489 Political Parties in the United States (3-0)3

A study of voting behavior, policy making, and the historical development of American political parties.

SS 492 Modern Germany (3-0)3

Political development, social and military history, and conflicts of the "-isms" in Germany from the founding of the Empire to West Germany's assumption of a position in the NATO Alliance. Relation of the nation's past to current problems of reunification, international position, and politics are studied through selected readings and discussions in seminar meetings.

SS 494 England: The Empire Since 1793 (3-0)3

A study of British foreign policy and the development of the Empire from the Napoleonic Wars to the formation of the present Commonwealth. Against a background of domestic social, economic, and political changes, the course will stress the British parliamentary system and its influence on other nations.

SS 495 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles" — the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 496 The Technological Future: The Social and Political Aspects (3-0)3

Lectures and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 497 Seminar: History or Political Science (3-0)3

[Permission of Instructor]

Independent directed study under the guidance of individual mebers of the department.

SS 499 Science and Religion: Science as a Social System (3-0)3

Consideration — through lectures and discussions — of the role of Science as a system of "Communication", in the contemporary sense in which that term is used in sociological, psychological, and communication-science studies. The latter phase of the course will stress in preview the relations between Science and Religion as social systems.

SS 500 Science and Religion: Religion as a Social System (3-0)3

The course will emphasize the role of Religion as a system of "Communication", in the sense defined in the paragraph above for SS 499. The latter part of the course will emphasize the interconnections, both conflict and cooperation, between Science and Religion.

SS 501 Afro-American History (3-0)3

An historical study of the patterns of racial relations and the participation of Afro-Americans in the social, economic, political, and cultural life of the United States. The topics covered include the origins and development of the slave system, the Civil War and Reconstruction, urbanization, the Civil Rights movement, and "Black Power."

TEXTILES

TE 211 — Chemistry and Physics of Textile Fibers — (3-1)3
[Offered both Semesters]

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 263 — Textile Systems I — (3-1)3

The preparation into yarn of staple cellulosics and man made fibers on the cotton system as well as filamentous man made fibers. These are presented analytically in terms of engineering principles or mechanisms concerned with functional use, structural design, and basic geometry of the yarns.

TE 264 — Textile Systems II — (3-3)4
[TE 263]

Same as TE 263 but involving wool in woolen or worsted yarn systems or blends of same with natural and synthetic fibers. A consideration of recovery processes for use of waste in varied fabrics is included.

TE 331 — Textile Systems III — (3-1)3
[TE 264]

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 332 — Textile System IV — (3-3)4
[TE 331]

A study of the more complex woven structures including jacquards, double fabrics, etc.

TE 403 — Modern Trends in Fabric Production — (2-2)3
[TE 332]

The production and utilization of non-woven, needle-punched and stitch bonded fabrics are discussed in detail. The

utilization of waste or unique processes for the production of yarns, fabrics and allied products are also covered.

TE 433 Technology of Knitting (2-2)3

A broad survey of the mechanics of knitting equipment and varied fabrics produced therefrom with special emphasis on fabric geometry.

TE 434 Advanced Knitting (2-2)3
[TE 433]

An advanced subject concerned with the construction and development of knitted fabrics with major emphasis on weft knit fabric geometry. Consideration is given to modern design of warp knitting mechanisms and fabric design. The student is encouraged to select a project for investigation in a specific area of knitting for a study in depth.

TE 459 Textile Systems V (3-0)3
[TE 332]

A study and analysis of the physical behavior of gray fabrics to mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved.

TE 460 Textile Systems VI (1-2)2
[TE 459]

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 472 Textile Evaluation (2-3)3
[TE 332 or equivalent]
[May be given each semester]

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 Instrumentation for Textiles (2-2)3
[PH 102 or equivalent]

A study of some mechanical, electrical, and electronic

methods for the measurement and control of such common textile process variables as pressure, temperature, liquid level, and fluid flow. The response of sensing elements, the modes of control, the characteristics of final control elements, and the interrelationship between those in closed loop systems are considered.

TE 482 Application of Scientific Methods to Textile Processes (3-0)3
[PH 201, MA 203, ME 216]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483 Engineering Design of Textile Structures I (3-0)3
[MA 203 and TE 332]

This subject correlates engineering properties of textile materials, engineering principles and textile methods in the design of textile structures with desired properties. Considered, are the following: the geometry and design of yarns for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes imposed by end use; and analyses of load-elongation diagrams of fibers and yarns.

TE 484 Engineering Design of Textile Structures II (3-0)3
[TE 483]

This subject deals primarily with three dimensional textile structures. The concept and objectives of the course are similar to that of TE 483. In addition, metallic fabrics and graphical solutions are considered.

TE 485 Statistical Quality Control — Textile (3-0)3
[MA 383, TE 331 or equivalent]

A study of statistical and administrative techniques relevant to the maintenance of product quality at defined levels. Sampling plans for variables and attributes are considered from the viewpoint of engineering economics.

TE 491 Textile Seminar (3-0)3
[Senior Status]

A survey is made of specific current releases of textile research and development in periodicals. Assignments for oral presentation are made and the defense of certain selected topics of this group is required.

NOTES

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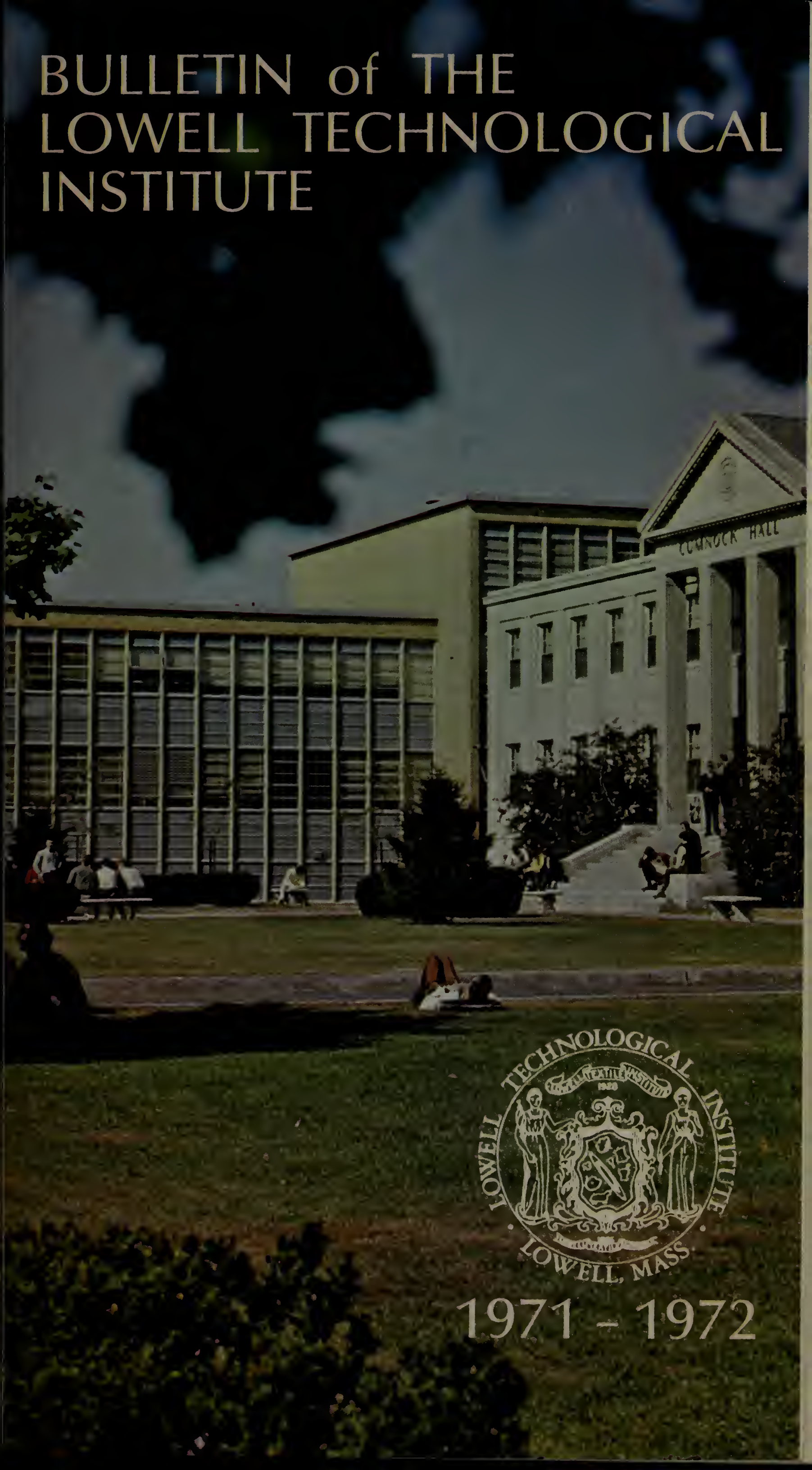

1971 - 1972

DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Dean of Admissions
Scholarship aid	Director of Financial Aid
Official transcripts	Registrar
Graduate studies	Dean of Graduate School
Summer school	Director of Summer School Director of Continuing Education
Evening study program	Director of the Evening Division
Alumni affairs	Alumni Office
Graduate placement	Placement Director
Library industrial corporate membership	Librarian
Conferences, special programs, public relations	Director of Public Relations
Sponsored research	Lowell Technological Institute Research Foundation

LOWELL TECHNOLOGICAL INSTITUTE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

:stablished 1895

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)ay programs leading to B.S., B.S. in B.A., M.S., and Ph.D. degrees

:vening programs leading to A.B.M., A.A.S., A.S., and A. Eng. degrees

Aember of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineers' Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

'otal enrollment — 8647
Day Division — 3630
Evening Division — 3357
Summer School — 1660
Graduate School — 417

Aen and women students from 20 states and 30 countries

uition: $200 for U.S. citizens who are residents of Massachusetts; $600 for all others

.T.I. Research Foundation conducts research and development work for government and industry.

he main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River, one half mile north of the center of Lowell, 25 miles north of Boston.

)ffice hours: 8:30 a.m. — 5:00 p.m., Monday through Friday

elephone number: 454-7811 (Area Code 617)

* * *

The Board of Trustees reserves the right to waive, at its discretion, any of ie rules and regulations stated herein, and to change any of the subjects or urricula, or portions thereof, without prior notice.

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ACADEMIC CALENDAR, 1971-1972

September 7, Tuesday	Freshman Orientation Week begins.
	Registration of graduate students begins.
September 8, Wednesday	Registration of seniors.
September 9, Thursday	Registration of juniors.
September 10, Friday	Registration of sophomores.
September 13, Monday	Classes begin.
September 22, Wednesday	Last day to register for new subjects or to drop a subject without approved academic petition.
October 11, Monday	Institute closed. Columbus Day Observance.
October 12, Tuesday	Monday schedule of classes.
October 25, Monday	Institute closed. Veterans Day Observance.
November 24, Wednesday, 6 p.m.	Thanksgiving recess begins.
November 29, Monday	Classes resume.
December 22, Wednesday, 6 p.m.	Christmas recess begins.
January 3, Monday	Classes resume.
January 6, Thursday, 6 p.m.	Classes end.
January 8, Saturday	Examinations begin.
January 14, Friday	Semester ends.
January 24, Monday	Registration of graduate students begins.
	Registration of seniors and juniors.
January 25, Tuesday	Registration of sophomores.
January 26, Wednesday	Registration of freshmen.
January 27, Thursday	Classes begin.
February 7, Monday	Last day to register for new subjects or drop a subject without approved academic petition.
February 21, Monday	Institute closed. Washington's Birthday Observance.
February 22, Tuesday	Monday schedule of classes.
March 24, Friday, 6 p.m.	Spring recess begins.
April 3, Monday	Classes resume.
April 17, Monday	Institute closed. Patriots Day Observance.
May 17, Wednesday, 6 p.m.	Classes end.
May 19, Friday	Examinations begin.
May 26, Friday	Semester ends.
June 11, Sunday	Commencement.

Normally, classes are held from 8 a.m. to 6 p.m., Monday through Friday.
This calendar is subject to change.

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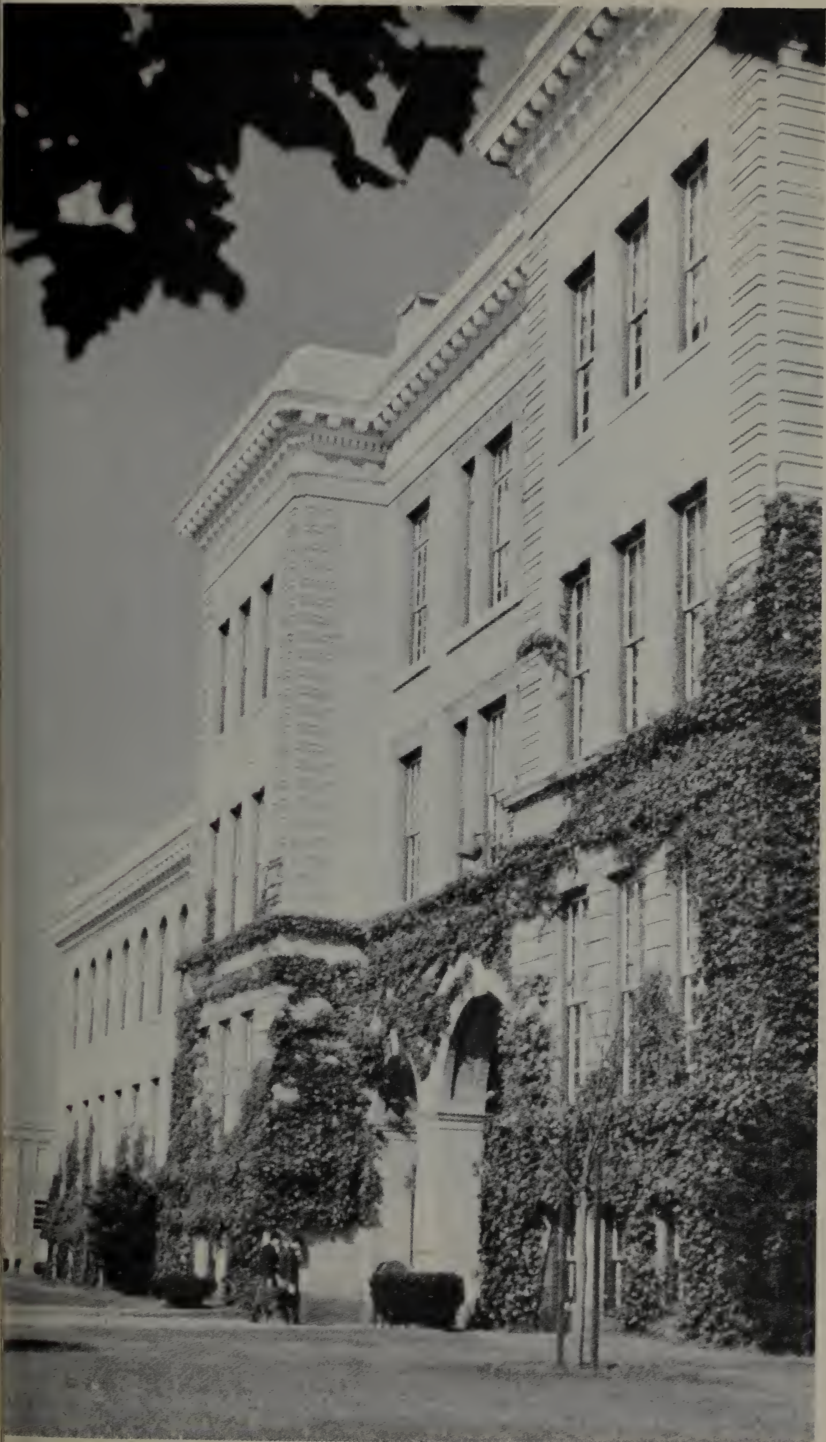

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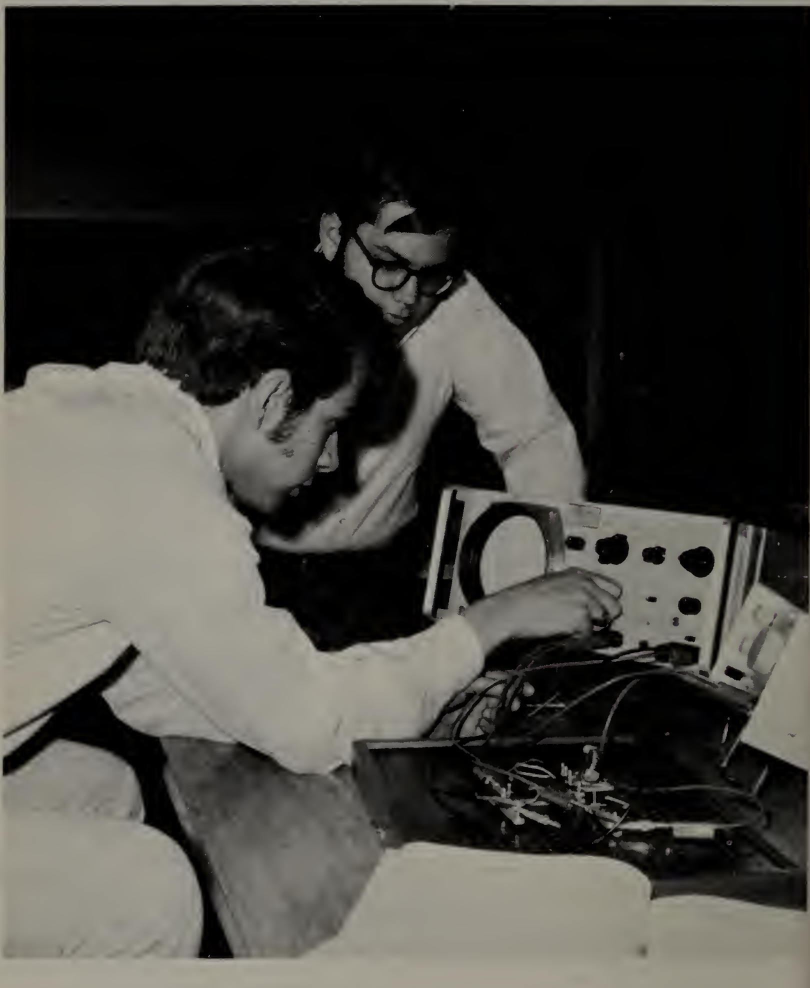

GENERAL INFORMATION

History and Aims

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry. In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration, meteorology, and biological sciences. In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to Lowell Technological Institute. The Institute grants Bachelor of Science in Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees. Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

The major aims of Lowell Technological Institute are to furnish sound educational programs in science, engineering, technology, business and management at both the undergraduate and graduate levels to cultivate in its students a professional attitude in their fields of concentration and to develop their ability for creative thinking. All education, and particularly in the fields of study offered at the Institute, must be based on a thorough grounding in the fundamentals upon which the study in the area of specialization is built; but, it must prepare the student for life in general and thus there must be an emphasis on the development of self-reliance and awareness of the interrelation between science, technology and industry and the society in which we live. For this reason, all curricula have a balance of basic material leading into more advanced theoretical and applied treatment of this knowledge with the inclusion of sufficient humanities to make a meaningful education for a productive life. Graduates are prepared to enter industry in the fields they have chosen or to continue for further education in graduate schools in preparation for research, teaching, or industrial positions.

Academic Organization

The academic programs and subjects offered are administered by the various Departments within the Divisions as listed:

- Division of Chemistry and Applied Chemistry
  - Department of Biological Sciences
  - Department of Chemical Engineering and Paper Engineering
  - Department of Chemistry
  - Department of Plastics Technology
- Division of Engineering Science
  - Department of Civil Engineering
  - Department of Electrical Engineering
  - Department of Mathematics
  - Department of Mechanical Engineering
  - Department of Meteorology
  - Department of Textile Engineering
- Division of General Studies
  - Department of Aerospace Studies
  - Department of Economics and Management
  - Department of Languages and Literature
  - Department of Physical Education
  - Department of Social Sciences
- Division of Nuclear Studies
  - Department of Physics and Applied Physics
  - Department of Radiological Sciences

Accreditation

The Institute is a member of the senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering. The ECPD has also accredited a two-year part-time program in civil engineering technology and a four-year part-time program in civil engineering technology. The chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate

study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus

The campus is situated 25 miles north of Boston, Massachusetts, in Lowell, a city of nearly 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 60-acre campus, situated on both sides of the Merrimack river, includes 13 main buildings, among them an auditorium-administration building, a library which is currently being greatly enlarged, six classroom-laboratory buildings, four residence halls and a gymnasium. A $4,500,000 nuclear science center is now in operation.

Alumni Memorial Library

The library, dedicated to Alumni of the Institute who served in World Wars I and II and the Korean conflict, has recently undergone an extensive expansion. The original building, constructed in 1951 by the Alumni Association, now houses the library's rare books, government depository collection, technical reports and a ground floor student activities area. The new addition, which is linked to the original building by means of ramps, houses most of the library functions. The main floor contains the lobby with its control desk, exhibition area, catalog, reserve book room, reference room as well as the administrative and work areas for the library staff. Two elevators serve the library building. The third floor houses the extensive periodical collections, including current issues as well as a microprint area. A section of this floor holds the abstracts and indices that serve as a guide to the periodical collections. The fourth floor houses the science and technology book collection while the fifth floor houses the collection of the humanities and the social sciences. On each floor shelving areas are mixed in with reading and lounge areas to give maximum accessibility to our collections. The lounge areas on the upper floors provide excellent views of the City of Lowell and the surrounding areas. The ground floor has a complete audio-visual area consisting of a master control room, a student listening room with thirty-one individual stations, six individual listening areas with equipment, an audiovisual office, a multi-purpose room seating 140 and a nine room radio station complex. The building seats approximately 1000 students and has a stack capacity of 450,000 volumes. A walkway under the side of the building adjacent to Smith Hall leads to the first aid station and the dormitory areas located behind the library.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $17,500,000. It includes such varied apparatus as an electron microscope analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contrbution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Dean of Admissions Office has received senior grades for this period. The responsibility of having these grades forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure no less than 12 months in advance of the expected date of enrollment.

The Institute does not accept part-time or special students, nor does it accept students at mid-year.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Dean of Admissions, Lowell Technological Institute, Lowell, Mass. 01854

Applications for admission are preferred by the Institute on or before April 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is requesting financial assistance must file a Parents' Confidential Statement with the Institute.

Application Procedure

A candidate for admission to Lowell Technological Institute in any of the fields of study open to undergraduates must:

1. Complete the first two pages of the admissions application form and the attached STUDENT DATA SHEET.
2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.
3. Submit the entire application form to the office of the secondary-school principal or guidance director with a request that the office fill out the remainder of the application form and mail it directly to the Dean of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the SAT Test during the period of April of the Junior year through March of the Senior year in secondary school. Letters, telephone calls, etc., will not be accepted in place of the official score card.

6. Applicants must indicate their chosen major field of study in the proper space provided on pages 1 and 5 of the application.

7. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

8. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

9. Upon receipt of a letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll. Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving a final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation. The responsibility for sending this final transcript to the Dean of Admissions Office rests with the student. Failure to instruct his secondary school to forward this final transcript could result in his being not accepted in the fall.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus Days. Personnel from the Dean of Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on October 29, 1971, January 14, 1972, and March 10, 1972 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must have been enrolled in a college preparatory program and must be a graduate of a secondary school approved by the New England Association of Colleges and Secondary Schools, Inc., the Regents of the State of New York, or a board of equal standing.

The New England Association of Colleges and Secondary Schools accredits schools and colleges in the six New England states. Membership in one of the six regional accrediting associations in the United States indicates that the school or college has been carefully evaluated and found to meet standards agreed upon by qualified educators. Colleges support the efforts of public school and community officials to have their secondary school meet the standards of membership.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high school work:

English	4 units
mathematics	2 units

American history and social studies	2 units
laboratory science	1 unit
electives	7 units

Advanced Placement

Lowell Technological Institute subscribes to the Advanced Placement Program of the College Entrance Examination Board which provides academic credit and placement for students who qualify. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English Proficiency Test and have the results sent to the Dean of Admissions prior to filing a formal application with the Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U.S.A. and, as stated above, request the results be sent to Lowell Technological Institute.

The **TOEFL Bulletin of Information** and Registration Form can be obtained in a number of cities outside the United States. They often are available at one of the following: American Embassies and Consulates, Offices of the United States Information Service (USIS), United States Educational Commissions and Foundations abroad, and Binational Centers. In addition, several private organizations distribute TOEFL bulletins, among them (1) the Institute for International Education (IIE) in Nairobi, Kenya; Kowloon, Hong Kong; Paris, France; and Lima, Peru, (2) the African-American Institute in Dar es Salaam, Tanzania; and Lagos, Nigeria, (3) the American Friends of the Middle East in Tehran, Iran; Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt, (4) the American-Korean Foundation in Seoul, Korea, and (5) the Bureau of Educational Research at Ewing Christian College, Allahabad, U.P. India.

Students who cannot obtain a TOEFL bulletin and registration form locally should write well in advance for them to: Test of English as a Foreign Language, Box 899, Princeton, New Jersey 08540, U.S.A. Students residing in Taiwan must apply to: Language Center, 2-1 Hsu-chow Road, Taipei, Taiwa, for the Special Taiwan editions of TOEFL publications.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that

required of U.S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U.S. students.

College Transfers

A student who wishes to transfer to Lowell Technological Institute from an accredited two or four year college must follow these guide lines.

1. The formal application for all potential transfer credit students to Lowell Technological Institute must be filled out in its entirety. An affirmative answer to Question 6B is a requisite.

2. Completed application forms are considered by the Committee on Admissions. Selection of potential transfer credit students is based entirely on its determination. Successful candidates will receive Form A application following this decision. Students denied transfer credit will be notified by mail.

3. The prospective student, in completing this form, MUST indicate the curriculum major he intends to pursue at Lowell Technological Institute. Lowell Tech reserves the right to limit assignment of transfer students to specific curricula.

4. The transfer credit applicant should list in Column I our course title, and number all Lowell Tech subjects offered comparable to those **completed** at another college or university. This enumeration should also include such comparable subject titles as are **in progress** or **in contemplation.**

5. Those subjects taken at other institutions of learning should be listed by course title and number in Column II and matched to each one being petitioned for credit appraisal at LTI. Subjects in progress or contemplated for completion must likewise be included.

6. Credit will not be considered in subjects where the applicant's grade is lower than "C", or from an institution granting neither an Associate nor Bachelor's Degree.

7. The third column should include catalogue page number and description of subjects taken at other recognized institutions. The fourth should include text required in the particular subject. The fifth must show the name of the institution where the applicant studies. **Do not mark Column Six.**

8. All completed information with the most recent transcript (s)

and catalogues must be received at Lowell Technological Institute Admissions Office no later than April 1. **There will be no exceptions.**

9. As courses so indicated in Form A are completed, it is the obligation and sole responsibility of the individual applicant to supply the official transcript record to LTI. Transcripts for subjects ending after the April 1st deadline, must be received by August 1st. The college will not solicit this required information.

10. Students completing the equivalent of one full year of college work, waive the SAT examination requirement. Others must forward official copies of SAT figures from Princeton, New Jersey.

11. One full year of physical education completed at another institution will be considered for transfer credit. This subject is a degree requirement at LTI.

12. International students are advised that unless they have completed two years of college level work in the United States at a University or College, they must take the TOEFL Examination in order to show proficiency in the English Language. No other English Proficiency Examination will be accepted.

13. Applicants are advised that it is a rule of Lowell Technological Institute that NO CREDITS will be allowed a student after he registers. It is therefore, imperative you list all credits you are hopeful of attaining before registration.

GED Certificate

In order to encourage and support non high school graduates in their effort to obtain a college education, Lowell Technological Institute recognizes the GED TEST as an instrument to obtain the Massachusetts High School Equivalency Certificate which we in turn honor in lieu of a high school diploma. This applies to applicants from the state of Massachusetts only, and students applying from other states should consult their Department of Education regarding how the GED Certificate is used as an equivalent to a high school diploma.

Lowell Technological Institute adheres to the terms of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) entitled "Nondiscrimination in Federally Assisted Programs," which states:

"No person in the United States shall, on the ground of race, color or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

STUDENT HOUSING AND SERVICES

Residence Halls

The LTI campus is oriented to a program that recognizes the educational advantages of both classroom instruction and extra-curricular activities. Residence hall living provides valuable exposure in this regard. Consistent with this philosophy, it is the policy of the Board of Trustees that all non-commuting students are required to live in the residence halls on campus insofar as our facilities permit unless excused by the Dean of Students. Excuses are reviewed periodically and may be cancelled should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students. When permission is granted to live off campus, the students must record, in the Dean of Students office, their off-campus local address. Further, the students are obliged to notify the Dean of Students office of any subsequent change during the academic year.

A list of off-campus rooms and apartments is provided, upon request, by the Housing Office to students who have been accorded permission to occupy other quarters.

Permission to reside at home is accorded in cases where the student lives within a normal commuting distance from the Institute or where financial hardship would be involved through living in a residence hall.

Upperclassmen are given choice of rooms and roommates in the spring of each year. Incoming freshmen are assigned dormitory space by the Housing Office in the order in which application data sheets are received.

Limited facilities are available for the housing of female students. Because of this limitation, spaces in the women's residence hall must be assigned on a priority basis. Applications will be processed in order of receipt.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application is approved by the Housing Office.

Room rental charge of $375.00 per year is payable upon registration prior to the Fall semester for the entire academic year.

The present schedule of fees for room and meals is currently under study and is subject to increase.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each student must supply his own

sheets, pillow, pillowcases, blankets, towels and personal linens or may subscribe to the laundry service provided for all resident students at a reasonable cost. Each occupant of a room is responsible for damage to furniture, equipment and interior sufaces. In the event of damage to public areas (corridors, lobbies, shower rooms, etc.) the cost will be apportioned among all residents of the building concerned.

Refunds

In the event of withdrawal, a refund may be made only when the following conditions are met:

1. All rooms must first be assigned.
2. When another student of LTI (not originally assigned a dormitory room) takes up **new** residence in the dorm then a refund may be made to a withdrawn student in the order in which the withdrawal took place without regard to a specific room or space.

The Institute reserves the right to reassign or transfer resident students within our dormitory buildings. In the event of such a reassignment or transfer of a student already in residence, the Institute shall not be liable for a refund to the former occupant of the room to which said reassignment or transfer is made.

The Institute reserves the right to utilize student rooms during vacation periods for conferences.

Residence Hall Counseling

The counseling staff of each residence hall is supervised by the Resident Advisor and coordinated by the Director of Residence Halls. They are responsible for the counseling, education, athletic, and social programs in the residence halls.

Under the guidance of the Resident Advisor, the floor counselors lend assistance and support to the development of interest in a strong responsible and active student organization. This necessitates imagination, skill, and initiative action on the counselors' part.

The entire residence hall staff assists the students, individually and collectively, in their orientation to residence hall life and communicates the philosophy that their total living and academic environment will be no better than the sincere contribution each of them makes to it.

The counseling staff is of great assistance to freshman resident students in familiarizing them with the various clubs, organizations, educational and cultural programs available at the Institute. With proper direction, extra-curricular pursuits can be a meaningful part of the student's total education.

Applications for residence hall counseling positions are accepted early second semester for the following year. Each applicant will be interviewed by a Resident Advisor and the Director of Residence Halls. All applicants will be notified of the results of their application prior to the end of second semester.

Residence Hall Regulations and Advice

These are general guidelines offered for the good of all resident students. Areas not concerned in these guidelines must be cleared through the Resident Advisor and the Dean of Students Office.

Room Conditions:

You will find that your room is already equipped with desks, desk chairs, beds, mattresses, mirror, dresser and closet. The rest is up to you.

You should bring your own pillow, blankets, sheets and towels, study lamps, rugs, draperies and any other furnishing you want. (Students may subscribe to the linen and towel service provided for all residents at a reasonable cost.)

Damages:

The Institute holds each student responsible for damage to property beyond normal wear and tear. Breakage or marring of furniture, defacing of walls, ceiling or floors, damage to windows, screens, or general vandalism to Institute property will result in a damage charge. Pictures may be taped to cement walls, and wood paneling; never to plastered walls. The use of nails or tacks on walls, woodwork or furnishings are prohibited.

Equipment Restrictions:

Cooking appliances, hot plates, and refrigerators are prohibited. Electrical appliances such as radios, phonographs, clocks, electric shavers, tape recorders, coffee pots, irons, are permitted. Upperclassmen may have televisions.

Room Maintenance:

For health and safety reasons, students should make beds daily, sweep floors, dispose of all trash and unplug electrical equipment when not in use. Cleaning equipment and light bulbs may be obtained from the custodian. Screen must be kept intact on windows and ledges kept clear - nothing may be hung from the windows.

Ironing:

Electric irons may be used only in laundry rooms and service rooms provided for this purpose.

PROHIBITED:

In the best interest of the student himself, his fellows, and the Institute, the following are prohibited:

1. Drugs: Students shall not bring into the dormitories, possess or store within the dormitories, marijuana, hallucinogens, barbituates, amphetamines and/or any other dangerous, illicit or illegal drug.

2. Alcohol: Students shall not bring into the dormitories alcoholic beverages of any kind.

3. Firearms, explosives, chemicals: Students shall not possess firearms, weapons, fireworks, gunpowder, chemicals or any other type of explosive in the dormitory at any time.

4. Pets: Students shall not keep pets in the dormitories and pets are prohibited on campus.

5. Incense: Burning of incense and/or other offensive materials is strictly prohibited.

6. Automobiles: Freshman resident students are not permitted automobiles.

Food:

Non-perishable food items are permissible if stored in suitable containers. Perishable items must be consumed within 24 hours. The Institute bans the use of hot plates.

Loss:

It is understood that the Institute assumes no responsibility for loss or theft of or damage to any property belonging to residents. Individuals are therefore urged to exercise prudence in securing their property and the Institute advises that each student carry personal property insurance. Rooms should be kept locked at all times when vacant.

Solicitation:

L.T.I. Clubs and Organizations or L.T.I. students may solicit if authorization from the Dean of Students or Director of Residence Halls has been given.

Bulletin Boards and Notices:

Residents are held responsible for information contained in notices on Bulletin Boards. Notices may pertain to special meetings, room sign-up, registration, etc. Permission to post other notices must have the Resident Advisor's approval.

Visiting:

The Board of Trustees in April, 1970, enacted co-ed visiting hours and set certain guidelines that must be followed. This policy was enacted on a temporary basis to be evaluated at a future

date. The Institute can expect a more permanent, all inclusive policy as a result of student-administrative committee recommendations.

Noise:

Students are reminded that they live under group conditions and that acts of thoughtlessness and irresponsibility jeopardize the opportunities of everyone to study and work in the residence halls. Noise should be kept to a minimum. When in doubt, be considerate of other persons.

Evacuation Procedure:

In case of an emergency, i.e., fire, bomb scare, etc. turn **on** room lights, close windows, and leave room with door closed and unlocked; then walk to the nearest exit. During emergencies, the building MUST BE EVACUATED.

Inspection:

Rooms may be inspected by Institute officials or counselor staff when considered in the best interest of the Institute.

First Aid:

The hours of the First Aid Dispensary, located behind the Library, are from 8:00 a.m. to 5:00 p.m. Report any illness or injury occurring at any other time to a member of the counseling staff.

Keys:

Keys are provided for each room. If lost, report to your floor counselor. Replacement fee is $2.00.

IMPORTANT:

Rooms are contracted for the entire academic year, and students are responsible for their room rent regardless of whether they occupy their rooms. No resident student is permitted at any time to maintain housing other than his residence hall assignment. Freshmen are assigned rooms by the Housing Office. Upperclassmen may sign up for the rooms they wish at the Housing Office or designated area. A change of room is not permitted except in rare instances and may be accomplished only after formal application is made to the Resident Advisor and approved by the Housing Office.

Dining Halls

All students living in the residence halls are required to purchase a dining hall meal ticket. The Leitch Hall dining room is for the use of Bourgeois and Leitch Hall residents. Residents of Smith Hall, Eames Hall, and the Annexes will obtain their meals in the Smith Hall dining room. The contract food service

provides two meals a day (breakfast and dinner), seven days a week, at a cost of $190.00 per semester.

An alternate meal plan is available which provides the same two meals Monday through Friday at a cost of $175.00 per semester.

THE PRESENT SCHEDULE OF FEES FOR ROOM AND MEALS IS CURRENTLY UNDER STUDY AND IS SUBJECT TO INCREASE. In the event of withdrawal, the cost of a dining hall meal ticket is refundable in accordance with the Tuition Refund Schedule. This charge is payable upon registration prior to each semester. The Smith Hall dining room is open at noon to provide food service on a cash basis for all students. The Eames Hall Snack bar is open intermittently during the day and evening.

THE ENTIRE FOOD CONTRACT PROGRAM IS UNDER STUDY AND IS SUBJECT TO CHANGE.

Health Service

Registered nurses are on duty for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with a parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Counselling

The counselling program, under the supervision of the Dean of Students Office, starts with the admissions procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Director of Student Counselling for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Director of Student Counselling.

Due to the large numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the counselling program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Counselling in the upper classes is generally conducted in scholastic matters by the Head of the Department concerned and in personal problems by the Dean of Students office.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE $10

1. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is acce ed for admission. For Massachusetts residents this an. unts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.
2. The application fee is NOT credited to the student's tuition.

TUITION **(per year)**

U.S. citizens who are residents of Massachusetts **$200**

Participants in the New England Board of Higher Education Regional Student Program **$200**

All others **$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U.S. citizens who are residents of Mass.... **$10.00 per cr. hr.**

All others .... **$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as

legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.

2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.

3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.

4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.

5. The residence of a wife follows that of the husband.

6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.

7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.

8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

ROTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND $60

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

Residence Halls .... per year $375

Each resident student will be billed for the entire academic year. In the event a student withdraws or is dropped at any time during the year, he is still responsible for the room charge and will be reimbursed only under the conditions as set forth on page 40.

THE PRESENT SCHEDULE OF FEES FOR ROOM AND MEALS IS CURRENTLY UNDER STUDY AND IS SUBJECT TO INCREASE.

LATE REGISTRATION FEE $25

A student who does not complete his registration (including the payment of all fees) by the close of the registration day assigned must pay this additional fee.

AUDITING FEE .... $5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE $15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES $5

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But Less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition

U.S citizens who are residents of Massachusetts	**$200**
Participants in the New England Board of Higher Education Regional Student Programs	**$200**
All others	**$600**
*Residence halls, per year	**$375**
Student activity and insurance fee	**$ 60**
ROTC deposit	**$ 25**
Books, supplies, and related miscellaneous expenses (approximate)	**$100**
*Meal fee per year	**$380**

THE BOARD OF TRUSTEES RESERVES THE RIGHT TO CHANGE ANY OR ALL FEES WITHOUT PRIOR NOTICE.

*THE PRESENT SCHEDULE OF FEES FOR ROOM AND MEALS IS CURRENTLY UNDER STUDY AND IS SUBJECT TO INCREASE.

*THE ENTIRE FOOD CONTRACT PROGRAM IS UNDER STUDY AND IS SUBJECT TO CHANGE.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

Fundamental to the principle of independent learning and professional growth are the requirements of honesty and integrity in the performance of academic assignments, both in the classroom and outside, and in the conduct of personal life. Accordingly, the Institute expects of its students the highest standards of intellectual integrity and thus the attempt of any student to present as his own any work which he has not performed or to pass any examinations by improper means is regarded as a most serious offense and renders the offender liable to immediate expulsion. The aiding and abetting of a student in any dishonesty is also considered a grave breach of conduct.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Full-Time Student

A full-time student is normally considered to be carrying the credit-hour load called for by the curriculum in which he is enrolled. However, since students are sometimes out of phase with the specified curriculum, for purposes of classification an undergraduate student may be classified as full-time if his approved program consists of at least 12 credit hours.

Attendance

An excused absence system is applicable. For regulations consult the KEY (Student Handbook).

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

..... A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(53-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester. Refer to THE KEY (Student Handbook) for method of calculation.

Any changes in courses or curricula must be accompanied by an academic petition.

Incomplete Grades

The grade of I for undergraduate students shall only be reported:
When a portion of the assigned or required class work or the final examination has not been completed because of necessary absence of the student due to serious illness or extreme personal or other circumstance beyond the student's control. If the student's record is such that he would fail the course regardless of the result of the missing work, he is to be given an F.

In order to qualify for an I, the student must obtain an Academic Petition form from the instructor. Such a form would not be issued if the quality of the work to date did not justify it. This form must be approved by the Dean of Students with copies returned to the instructor and filed with the Registrar.

A student can obtain credit for an I only by finishing the work of the course within two weeks from the end of the semester. The grade of I is converted to F is the course requirements have not been satisfied by this time. Exceptions to the two-week deadline may be requested on the Academic Petition and approved by the Dean of Students in cases of protracted illness or critical personal problems or for academic reasons at the request of the instructor. The initiative for removal of the I rests with the student, but faculty members giving an I must be responsible for making suitable arrangements for its removal.

An I on a final grade report is calculated as an F in arriving at a temporary rating. When the I is later converted to a grade, the permanent record is changed and the student notified.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

PROBATION AND DISMISSAL — ACADEMIC

Probation

A student is automatically placed on probation under the following conditions:

a. When the student's semester rating is less than 1.35

B. When the cumulative rating of a student not on probation is less than the appropriate value

Freshman Year-end	1.40
Sophomore Mid-year	1.45
Sophomore Year-end	1.50
Junior Mid-year	1.55
Junior Year-end	1.60
Senior Mid-year	1.65

The probationary period covers theentire regular semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the institute in any public function or extracurricular activity and may not hold or run for any class or other offices during the term of probation, and is allowed no unexcused absences from classes.

Dismissal

A student is automatically dropped from the Institute for at least one semester under the following conditions;

A. When the student's semester rating is below 0.70

B. When the student's semester rating is less than 1.35 for two consecutive semesters

C. When the student, while on academic probation, fails to achieve the cumulative rating required in Item B above, effective with the Class of 1972.

Upon request of a student who has been notified of impending academic dismissal from the Institute by the above conditions, the Dean of Students, in the case of a freshman, and the appropriate Department Head, in the case of an upperclassman, will grant the student a hearing to review that student's case to ascertain if extenuating circumstances exist which would justify further consideration.

A student dropped from the Institute should see Readmission Policies. (p. 53)

PROBATION AND DISMISSAL — DISCIPLINARY

A student is placed on disciplinary probation by the Dean of Students when in his opinion a student has violated a basic rule of conduct or an established rule of the Institute. The probationary period covers the entire semester in which the violation took place. The length of time of the censure can be a longer period of time.

A student who violates the basic tenet of disciplinary probation may be dismissed from the Institute.

If the original violation is of a serious nature, the Dean of Students may dismiss the student without benefit of a probationary period.

Any student on disciplinary probation may not represent the Institute in any public function or any other extra-curricular activity and may not hold or run for any class office or other office during his term of probation, nor is he allowed to cut any classes or laboratory sessions.

READMISSION POLICIES

Requests for readmission will be handled by the Dean of Students Office. All correspondence should be sent to this office. The procedure to follow and all information needed is listed below.

1. Students desiring consideration for readmission must submit pages 1 and 2 of our application.
2. Student Data Sheet must be completed in its entirety.
3. A Check in the amount of $10.00 made out to Lowell Technological Institute must be included.
4. A letter giving original date of entrance to this college, date and **reason** for withdrawal and a brief resume of what you have done since you left L. T. I. must accompany the application. (N.B. If withdrawal was for medical reasons, you must include a doctor's certificate certifying ability to attend school again).
5. Students desiring transfer credit should supply an official transcript sent to us by the colleges attended. Only those courses graded in "C" range or better will be considered. Those students who withdrew because of scholastic difficulty must have had prior approval on the required credit form obtained at the Registrar's office in order to have their courses considered for credit.
6. Completed applications for September readmission must be received no later than May 15.

 . Completed applications for February readmission must be received no later than January 1.

7. When the Dean of Students deems it necessary a student will be asked to make himself available for an interview.
8. Only when all of these items have been received in the Dean of Students office will the application be considered for readmission.

 . Final decision will be made by the Dean of Students and/or the Department Head for upperclassmen as to whether or not readmission would serve the best interests of the student and the Institute. Approval of readmission is not automatic and all decisions will be final.

9. A letter will be sent notifying you of the decision from the Dean of Students Office. No notification will be given by telephone or in person.

RULES OF CONDUCT

The Board of Trustees recognizes the dual obligation of the Institute to insure the orderly pursuit of its proper functions at all times while preserving the rights of individuals and groups to freedoms guaranteed by our national and state constitutions and normally prevailing in the academic community. The Board of Trustees recognizes and defends the right to open discussion, the right to hold and articulate one's own beliefs and convictions, the right of peaceful assembly, the right to petition, the right to distribute handbills and circulars, the right to a fair hearing, and such other rights as are inseparable facets of the concept of academic freedom and are indispensable for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. The basic distinction to be made is that between those activities which are consistent with our obligation as an academic institution dedicated to free inquiry and free expression and to safeguarding the freedom to teach and the freedom to learn and those activities which are inconsistent with this obligation. It follows that there is a responsibility for the Institute to draw clear distinctions between conduct on the part of members of the Institute community and visitors to the Institute which is acceptable and that which is not. The rules set forth below are effective in accordance with the existing laws of the Commonwealth and the nation.

The following activities are among those which are considered unacceptable because of their adverse effect on the preservation of freedom or on the orderly pursuit of Institutional work:

1. Obstruction or disruption of teaching, research, administration, or other Institute activities, including the Institute's public service functions or of other authorized activities, on Institute owned or controlled property;

2. Obstruction of the free flow of traffic, both pedestrian and vehicular, on Institute owned or controlled property;

3. Physical abuse or detention of any person on Institute owned or controlled property or at any Institute sponsored or supervised functions, or conduct which endangers the health or safety of any person;

4. Theft of or damage to property of the Institute or of property of a member of the Institute community or the property of a visitor to the Institute;

5. Unauthorized entry to or use of Institute facilities, including both buildings and grounds;

6. Violation of Institute established policies or regulations, including regulations in the Catalogue, the "Key" and other publications pertaining to student organizations, student, faculty, administrative staff, non-academic employees and visitors conduct, the use of Institute facilities, or procedures concerning the time, place and manner of public expression;

7. Violation of rules governing residence in Institute owned or controlled property;

8. Use, possession, or distribution of narcotic or illegal drugs on Institute owned or controlled property, except as expressly permitted by law;

9. Failure to comply with directions of Institute police and any other law enforcement officers acting in performance of their duties and to identify one's self to these officers when requested to do so;

10. Illegal or unauthorized possession or use of firearms, explosives, dangerous chemicals or other weapons on Institute owned or controlled property;

11. Failure to comply with the directions of Institute officials acting in the performance of their duties;

12. Disorderly conduct, breach of the peace, and aiding, abetting or procuring another to breach the peace on Institute owned, or controlled property or at Institute sponsored or supervised functions.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors — graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors — graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors — graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Defense Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates, through the College Scholarship Service, Princeton, New Jersey.

Students may obtain applications and information regarding these programs at the Financial Aid Office, O 112.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Financial Aid Officer before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Alumni Association Scholarships

The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

AFROTC College Scholarship Program

High school students desiring information on the 4-year AFROTC College Scholarship Program should see their school guidance counsellors or write directly to AFROTC (OTTA), Maxwell AFB, Alabama 36112 for further information. Normal deadline application is 15 November each year.

Scholarships are provided on a competitive basis to a limited number of male and female cadets entering Aerospace Studies 200-300 in the Air Force ROTC four year program. The scholarship covers full tuition costs, books, laboratory expenses and incidental fees. A scholarship earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable standards. Cadets also receive $50. per month subsistence allowance.

Greater Lowell Home Builders Association

This organization has established a $200 scholarship for a deserving resident of Greater Lowell. The scholarship will be renewable for four years on the condition that satisfactory grades are maintained.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass., West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

Outside Scholarship Assistance:

The Afro-American Society at L.T.I. has compiled a list of Private, Public, and Federal Scholarships, Funds, Fellowships, and Loan Programs that are available to disadvantaged persons.

The Financial Aid Office has copies of this list which will be sent upon request. Correspondence should be addressed to the Director of Financial Aid, Lowell Technological Institute, Lowell, Massachusetts 01854.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Corporation Scholarship

The Allied Chemical Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

Boston Paper Trade Association Awards

One award, of $300, is open to upperclassmen enrolled in the Paper Engineering Department. Awards are based on character, proven interest in the Paper Industry and academic performance.

Roland E. Derby, Sr. Memorial Scholarship

This Scholarship established in memory of Roland E. Derby Sr. provides a $500 scholarship to a sophomore student who is a candidate for a degree in Chemistry, Textile Chemistry, or Chemical Engineering. Selection by the Scholarship Committee shall be based on scholastic achievements, but due consideration shall also be given to financial need. The scholarship shall be renewable for the Junior and Senior year provided the recipient maintains a satisfactory academic record.

James L. Dillahunty Scholarship

The James L. Dillahunty Scholarship of $250.00 is awarded on a three-year basis to a candidate for degree in Engineering, Sciences and Industrial Management. This scholarship was donated by Mr. James L. Dillahunty, class of 1967.

Foster Grant Scholarships

The Foster Grant Company, Inc., of Leominster, Mass., makes available on a one-year basis two scholarships to deserving students in Plastics Technology who are residents of Massa-

chusetts. Preference is given to sophomores living in the Leominster area; however, if there are no applicants from that area, other candidates may be chosen. Scholarship, personality, and overall student contribution to extracurricular activities are the general criteria used in selecting the recipients.

General Electric Scholarship

The General 'electric Company has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics Technology.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

Nylon Engineering, Inc. Scholarship

This scholarship in the amount of $250.00 is awarded annually by the Nylon Engineering, Inc. to an upperclassman majoring in Plastics.

Mobay Scholarship

The Mobay Chemical Company of Pittsburgh, Pennsylvania has made available on a one-year basis a scholarship to be awarded to a deserving upperclassman majoring in Plastics Technology.

Paper Engineering Department Scholarships

Ten or more scholarships with annual stipends of $500 are available to upperclassmen and selected graduate students in Paper Engineering who fulfill the scholarship requirements of a minimum of 2.0 cumulative rating. These scholarships are normally maintained from year to year provided the student maintains his academic rating.

Contributors to the Scholarship Fund include the following:

Bertrand Hopper Memorial Fund
Byron Weston-Crane Company
Carter Rice Storrs and Bement, Inc.
Weyerhaeuser Company
Erving Paper Mills
Fraser Paper, Ltd.
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Tileston and Hollingsworth

Rohm and Hass Corporation Scholarship

The Rohm and Hass Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

S.M.E. Awards

Merrimack Valley Chapter 113, Society of Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The S.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

William C. Smith Trust Fund Scholarship

This fund has been established to provide scholarship assistance to students majoring in Chemistry.

Society of Plastics Engineers Scholarships

Two scholarships are granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to upperclassmen majoring in Plastics Technology.

Uniroyal Incorporated

This Foundation has established scholarships for students who have successfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value. Applicants must be in need of financial assistance, and reeipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry or Textile Chemistry in the amounts of $225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

Available to Undergraduate & Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3% beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack for financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

SME Award. The Merrimack Valley Chapter, Society of Manufacturing Engineers awards $100 to a member of the Student Chap-

ter of the SME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scho-

lastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

The Wall Street Journal Student Achievement Award

This award recognizes the senior in Business Administration or Industrial Management who has achieved the best combination of academic and extracurricular excellence. The award consists of an engraved paperweight, a year's subscription to the Wall Street Journal, and a plate on the permanent plaque established for the award winners.

OTHER ASSISTANCE FOR MASSACHUSETTS Residents Only

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upperclassmen. For full information write to:

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1,000 a year for undergraduate school, or $1,500 a year for graduate school. There is no interest charge on such loans while the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 7% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Massachusetts 02116
Telephone 426-9434

Cooperative Study Program

The First Naval District has approved Lowell Technological Institute as Sponsor of its Cooperative Work-Study Program at the Boston and Portsmouth Naval Shipyards.

Students will undertake a five-year program in their field of specialization — electrical, electronic, chemical, civil and mechanical engineering, increasing their experience and capabilities in subsequent on-the-job training at either shipyard. Successful students will earn the bachelor of science degree.

Information concerning this program may be obtained by writing the First Naval District Headquarters at Charlestown or the Director of Admissions, Lowell Technological Institute.

PLACEMENT

Industrial Training Program

The Placement Office maintains two basic functions. One is to counsel the senior planning to take recruiting interviews; the other is arranging the dates of interviews for the representatives of the recruiting companies and agencies.

In the counselling process the Placement Officer reviews the student's transcript with him, discussing his points of strength and weakness. The elements of the recruiting procedure are explained so that he may be properly prepared for the ensuing interviews.

Approximately one hundred and eighty companies and government agencies recruit on the LTI campus. The companies represent a cross-section of industry in the country ranging from the so-called giants down to those of relatively small size. Geographically, they are located in the Northeast, the Southeast and the Mid-West with a few from the Far West. Thus, the seniors get fairly broad exposure to business opportunities.

SUMMER SCHOOL

The Summer Sessions are designed primarily to serve the following areas of interest:

1. UNDERGRADUATE CREDIT PROGRAM

Two six-week sessions, paralleling the two 15-week academic year semesters, stress fundamental credit offerings in mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

These sessions provide an opportunity for deficiency clearance and for advanced standing.

2. GRADUATE CREDIT PROGRAM

Selected graduate credit subjects are offered for fully matriculated students who have been admitted to advanced study by the L.T.I. Graduate School. The Dean of the Graduate School must approve all offerings and registration is carried out through the Graduate School Office.

3. PRECOLLEGE REFRESHER PROGRAM

This five-week, noncredit program caters to prospective L.T.I. freshmen who require additional background to fulfill minimum entrance requirements.

Students must first apply for fall admission; the Dean of Admissions designates the subjects or subjects required for coverage of minor deficiencies in the high school background. Subject areas include: English, mathematics, chemistry, and physics for engineering applicants; English, mathematical analysis, and general science for business administration majors.

4. PROFESSIONAL ADVANCEMENT PROGRAM

Industry-sponsored, noncredit courses may be arranged on a one- to three-week schedule during the summer. These offerings are similar in scope to the **continuing education** courses conducted during the academic year.

Summer Evening offerings are conducted through the Division of Evening Studies in a single, six-week session. Credits apply **only** to Evening Division programs.

The Summer School is operated entirely without financial assistance from the Commonwealth of Massachusetts.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

THE GRADUATE SCHOOL

The Lowell Technological Institute Graduate School, which was founded in 1935, offers advanced studies, including professional training and research leading to graduate degrees in many fields of engineering and in certain areas of pure and applied science. The School offers Master of Science degree programs in the following fields: Chemical Engineering, Chemistry, Electrical Engineering, Mathematics, Mechanical Engineering, Nuclear Engineering, Paper Engineering, Physics, Plastics, Polymer Science and Textile Engineering. Programs leading to the Doctor of Philosophy degree are also offered in Chemistry, including a Polymer Science option, and in experimental and theoretical Physics, including Solid-State, Nuclear, High Energy, Atomic, Atmospheric and Biophysics options. In addition to the day classes intended primarily for full-time graduate students, the Graduate School offers some evening courses through the Division of Evening Studies mainly for the convenience of part-time students primarily interested in advanced professional training. The courses offered in the evening are equivalent in every respect to those offered to the day students for they are simply evening sections of courses offered during the day. There are currently 151 graduate students enrolled in degree programs for advanced professional training in these Evening Division courses out of a total Graduate School enrollment of 417 students. These part-time students are primarily from the large industrial companies nearby the Institute located principally in the Merrimack Valley. New graduate programs in Applied Mathematics, Computer Engineering, Environmental Studies, Management Science, and Systems Engineering are currently under consideration by the Graduate School Executive Committee and it is hoped that these programs will be instituted in the Fall of 1971. Programs of this type, which would include as well the graduate programs in Plastics, Paper, Textiles and Nuclear Engineering are in wide demand by industry in New England and in Massachusetts in particular. These programs serve as excellent supplements to the standard curricula in the basic engineering and science areas which would include Chemistry, Physics, Chemical Engineering, Electrical Engineering and Mechanical Engineering. In June of 1970, there were 43 Master of Science degrees and 3 Doctor of Philosophy degrees granted through the Graduate School at LTI. For further information concerning the graduate programs, please consult the Graduate School Catalog.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Office, the Research Foundation, the Pinanski Nuclear Center, WLTI, the Research Foundation, the Alumni Memorial Library and the Summer School, the college provides such services to industry and the community as the following:

Industrial seminars and conferences;

Technorama, science fair for area high schools;

Consultive opportunities with administration and faculty;

Special radio and television programs;

Collaboration with the Agency for International Development in its foreign aid programs;

Participation with local and state agencies in the solving of ecological problems.

For information concerning these programs, address the Department of Public Relations at the Institute.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers Undergraduate Programs leading to Associate and Baccalaureate Degrees, and Master's Degree satellite programs with area industries. The majority of the degree programs are in the fields of science, engineering technology and business administration.

Additionally, individual subjects in mathematics, science, technology, engineering, business, and general studies may be taken as a special student. An increasing number of students who have completed our Associate Degree Program on a full-time basis and have become full-time employees are continuing their education on a part-time evening basis in the Baccalaureate Programs.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers In-Service Training Programs limited to employees of the Commonwealth and cities and towns within the Commonwealth. These undergraduate programs lead to Associate and B.S. degrees in Civil Engineering Technology, Associate in Business Administration (in either Accounting or Data Processing), and Bachelor in Business Administration. The Associate and B.S. Degree programs in Civil Engineering Technology are accredited by the Engineers' Council for Professional Development.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION

Established in 1950 by the Board of Trustees of the Lowell Technological Institute, the Research Foundation is a not-for-profit organization that does research in a wide variety of fields. The operation is fully self-supporting from income derived from its industrial and government sponsors.

The Research Foundation is housed in a one-story modern building across the Merrimack River from the Institute's main campus. Initially its prime purpose was to answer the needs of the Lowell Technological Institute for facilities and staff to perform basic and applied research in textiles and related subjects. As the Research Foundation expanded, a diverse and growing program of research and development activities increased extensively, and projects have moved into the fields of chemistry,

leather, paper, plastics, electronics, physics, oceanography, nuclear engineering and environmental pollution, in addition to management and economic development assignments.

The Research Foundation is presently composed of five major divisions: Electronics and Physics, Ionospheric Science, Environmental Pollution, Economic Development, as well as a Testing Division.

The Electronics and Physics Division is primarily interested in electronics, electro-mechanical design and development, applied electronics and physics, electro-magnetic interference reduction, power supply technology, and metrology services.

The Ionospheric Science Division is concerned with instrumentation, measurements, data analysis and theoretical studies of the ionosphere and its effect on communications.

The Environmental Pollution Division's areas of interest are air and water pollution sampling and analyses, waste treatability and reuse studies, and plant project design consulting.

The Economic Development Division works in the areas of economic studies, marketing, general management, and manufacturing services.

The Testing Division is mainly concerned with the testing and evaluation of a wide variety of materials submitted by industrial and Government sponsors.

Students are encouraged to visit the Research Foundation.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts, 01854.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four executive officers elected by the student body and the officers of each class. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Afro-American Society

This organization assists and organizes whatever separate groups and/or function that will allow those individuals dedicated to the benevolent welfare of black people to invest their energies.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Amateur Radio Club

This organization is enjoined to promote the fraternity of Amateur Radio at Lowell Tech and specifically to promote the fellowship of amateur radio through on-the-air activities. To aid interested individuals in obtaining their amateur radio license as well as helping current license holders advance their grades.

Amateur Rocketry Organization

The purpose of this organization is to conduct experiments, research projects and other educational activities designed to increase the knowledge of its membership in the science of modern rocketry and in the technologies related to it.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier cur-

rent radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition has extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multipurpose room and radio studios.

WLTI was originally organized as The Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10 Kw FM transmitter. Work is now under way on the renovation of this equipment and the licensing of the station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Bridge Club

The duplicate Bridge Club is open to all students and faculty who are interested in either learning or playing bridge. The club meets every Wednesday in informal session in Eames Lounge and refreshments follow each meeting.

Cadet Advisory Council

The purpose of Cadet Advisory Council is to handle grievances and recommendations concerning actions and policies of the Cadet Corps.

Cheerleaders

The Cheerleaders encourage and promote the enthusiasm of the Student Body as well as that of the team members at L.T.I. basketball games.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Students Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and .life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interests and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen. They are also responsible for publishing the student handbook, THE KEY.

Current Issues and Affairs Committee

Membership in the society is open to all members of the academic community at Lowell Technological Institute. The objectives of the committee are (1) to provide a forum for the discussion of current events in the educational, political, social and economic fields, and (2) to establish a vehicle for the implementation of those measures believed essential in the foregoing fields by the majority of the members; all implementation procedures conforming to law and rules and regulations of the Institute.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

There are fraternities — Delta Kappa Phi, Kappa Sigma, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, Sigma Phi Omicron, and Tau Kappa Epsilon — all have their own fraternity houses. All provide social life off campus and four are national fraternity

affiliates. The Inter-fraternity Council fosters the common interests of the seven and sponsors interfraternity social and athletic events.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

Interdormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Karate Club

Instruction in Karate is made available to members of this organization.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units. Pershing Rifles maintains a residence which houses several members and is the center of social activity for the organization.

Pickout

The Pickout is the college yearbook. Its student staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

American Association for Textile Technology, Student Chapter
American Chemical Society, Student Chapter
American Institute of Chemical Engineers, Student Chapter
American Society of Civil Engineers, Student Chapter
American Meteorological Society, Student Chapter
American Nuclear Society, Student Chapter
American Society of Mechanical Engineers, Student Chapter
Biology Club
Industrial Management Society
Institute of Electrical and Electronics Engineers, Student Chapter
MALTI (Mathematics Association of LTI)
Sigma Kappa Psi
Society for Advancement of Management, Student Chapter
Society for Manufacturing Engineers
Society of Physics Students
Society of Plastics Engineers, Student Chapter
TAPPI (Student Chapter, Tech. Association of Pulp & Paper Industry)

Religious Groups

United Campus Ministry
Rabbi Benjamin Tumim, Chaplain; Hillel Counsellorship
Reverend K. Gordon White, Chaplain, Iona Fellowship
Reverend Paul T. Walsh, Chaplain, Newman Community
Reverend Joseph D. Flynn, Chaplain, Newman Community
Reverend John P. Sarantos, Chaplain, Phanar Club

THE UNITED CAMPUS MINISTRY OF LOWELL is a federation of students, spiritual and faculty advisors of the various religious organizations of Lowell Technological Institute, Lowell State College and Lowell General Hospital School of Nursing, which sponsors ecumenical programs throughout the academic year. For information, contact Rev. Paul T. Walsh, the Chairman-chaplain at the NEWMAN CENTER.

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Community

Through the combined efforts of the spiritual advisors and many local friends, the Newman Community now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI, Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Service Club

The co-eds at the Institute have formed this organization to be of service to the Institute, and in particular, the athletic department. Some projects undertaken by members are greeting visiting teams, assisting visiting coaches in any way possible, score keeping, time keeping, working with judges. The girls also serve as usherettes, selling programs, etc.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Sororities

BETA TAU Sorority was recently established on campus to promote good fellowship and high scholarship. As a service sorority, BETA TAU participates in many campus and community activities.

PHI SIGMA RHO, established in 1937, is the oldest sorority on campus. Its members enjoy the bonds of sisterhood as well as take an active part in social, civic, and recreational activities.

The activities of PHI SIGMA RHO and BETA TAU are governed by the Intersorority Council.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The weekly publication offers excellent journalistic and business experience to those who work on its staff.

Colonel Charles L. Vacanti Squadron of the Arnold Air Society

The Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs, charitable works, and aerospace exhibits during the year. Community services include visits to the veterans hospitals, the annual food drive for the needy and the annual blood drive. The Squadron sponsors the annual Military Ball, which is a social highlight of the year.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose it to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

Veterans Club

The objectives of this club shall be to present programs of interest and importance to the membership of the club, to service all veterans whether or not they are members of the organization, to assist members in finding part-time and summer employment, and to actively participate and become interested in academic and non-academic areas of concern within the Institute.

Veterans

G. I. Bill

Veterans attending LTI may apply for financial assistance under the GI Bill. Application should be made to your local VA Office for details. Proof of your student status should be obtained by presenting your acceptance from the Admissions Office and, upon registration, the Registrar's Office should be requested to notify the VA as to your student status.

Certificate of Eligibility

Veterans whose service is credited to Massachusetts are entitled to free tuition for four years at Massachusetts colleges. In order to obtain the Certificate, you must present your discharge papers (DD 214) to the Adjutant-General's Office in the State House in Boston. Upon receiving verification, you should bring it to the Massachusetts Department of Education at 182 Tremont Street, Boston and request the Certificate. A request should then be filed with the Office of the Registrar during registration to inform the Department of Education as to your status and also with the Bursar's Office to the effect that you will present the Certificate to them when you receive it.

THE THREE CATEGORIES BELOW CLASSIFY OUR STUDENTS AS VETERANS IN TERMS OF THE PHYSICAL EDUCATION REQUIREMENT AT THE INSTITUTE:

1. National guard — six-year period — discharged and military obligation completed.
2. National guard — six-months active duty completed and serving five and one-half years of reserve training.
3. Student who fulfills military obligation on active duty in the armed services.

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men and women who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC), the first two college years, and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Four-Year AFROTC Program or the Two-Year AFROTC Program. Students electing the Four-Year Program will take the General Military Course during their freshman and sophomore years and the Professional Officer Course during their junior and senior years. They will attend four weeks of field training during the summer between the sophomore and junior years. As members of the Four-Year Program they are eligible to compete for AFROTC Scholarships. For acceptance into the POC, the Four-Year Program student must pass a physical examination, an Officer Qualification Test, and possess an acceptable academic rating. To qualify for enrollment in the Two-Year Program, a student must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. They must also meet certain physical standards, pass an Officer Qualification Test, and possess an acceptable academic rating. Further, they must successfully complete a six-week Field Training Course before they can be accepted into the Professional Officer Course. Students in the Two-Year Program are not eligible to compete for AFROTC Scholarships. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the Institute and the United States Air Force. Students in the Professional Officer Course receive a $50.00 a month subsistence fee. Additionally, scholarships are available to a limited number of cadets in the 4-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. They serve on active duty in the Air Force in a speciality as close as possible to their academic training consistent with AF needs.

GENERAL MILITARY COURSE

FRESHMAN YEAR

		First Semester	
AS	101	U.S. Military Forces in the Contemporary World I	(1-1) 1
		Second Semester	
AS	102	U.S. Military Forces in the Contemporary World II	(1-1) 1

SOPHOMORE YEAR

AS	201	U.S. Military Forces in the Contemporary World III	(1-1) 1
AS	202	U.S. Military Forces in the Contemporary World IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

		First Semester	
AS	301	Growth and Development of Aerospace Power I	(3-1) 3
		Second Semester	
AS	302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

		First Semester	
AS	401	The Professional Officer I	(3-1) 3
		Second Semester	
AS	402	The Professional Officer II	(3-1) 3

The AFROTC program is recognized as academic but of a highly specialized nature. It is not a requirement for graduation and students may not use more than six (6) credit hours of the Professional Office Course (junior and senior year subjects) in substitution for other subjects taken for graduation. Subjects taken in the ROTC program in the freshman and sophomore years are to be taken in addition to all other subjects listed in the

various curricula. Academic credit is given for all ROTC subjects taken and passed and the grades will affect the student's academic rating. Unless otherwise specified in the section on each curriculum, the six credit hours of advanced ROTC may be substituted for General Electives. For the most part, the allowable substitution of the six ROTC credits for other credits can be made only in the senior year. Business Administration is the only exception to this regulation (refer to Business Administration curriculum's Elective Course Guidelines for all BA Options for details).

CORPS TRAINING

Corps Training is conducted one hour each week. It is an assembly of the entire cadet corps under the direction of the cadet officers and staff. The General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to plan, organize and supervise cadet activities. During periods of inclement weather, Corps Training is conducted indoors and consists of programs to familiarize cadets with the life and work of Air Force officers and the base environment in which he functions. Experts in the fields of Defense Policy and other current affairs subjects also lecture in the AFROTC Enrichment Program to broaden the student's appreciation in these areas.

FIELD TRAINING

Each cadet must attend field training during the summer before entry into the Professional Officer Course. Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $225.00 for the four-week Field Training and $330.00 for the six-week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The

program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of dual and solo flight instruction by a FAA certified civilian flying school at government expense.

CADET DECORATIONS AND AWARDS

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, The Alumni Medal, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the "Air Force Times" Award, and the Vandenberg Cup.

In addition, the Department of Aerospace Studies confers several medals and awards, among them the Distinguished Military Cadet Award, for outstanding performance in various fields.

Distinguished AFROTC Graduate Awards, based on academic and military achievements, are given to outstanding graduates. These awards constitute an advantage in competing for a Regular Air Force commission.


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ATHLETICS AND RECREATION

Athletics are a part of the total program at Lowell Tech, and essential to the overall development of the individual. New and extensive facilities and a competent professionally trained staff provide numberless opportunities for students to participate in a variety of activities.

A beautiful new, well-equipped physical education building includes a gymnasium, with a seating capacity of two thousand, an all-purpose gym of equal size to the main gymnasium, a collegiate style swimming pool, a wrestling and judo room, weight training facilities, a gymnastics area, two handball and three squash courts, home and visiting team dressing rooms, a modern rifle range, and locker rooms for students and faculty with more than two thousand lockers available.

New athletic fields and a skating rink are located in the area adjacent to the physical education building.

Plans are underway to construct an Intercollegiate Boathouse for L.T.I. on the Merrimack River in Lowell.

The Athletic Association is funded by student fees and provides extensive opportunities for student participation in Intercollegiate, Intramural and Recreation programs. All students are members of the Association and are admitted free to all home athletic contests.

Intercollegiate Athletics: Lowell Tech has intercollegiate competition in seventeen sports. Teams are scheduled in Soccer and Cross Country in the Fall; Basketball, Hockey, Wrestling, Gymnastics, Swimming, Skiing, Squash, Bowling and Rifle in the Winter; Baseball, Track Golf, Tennis, Crew and Lacrosse in the Spring.

Intramurals: The intramural program at L.T.I. is extensive. The three leagues — Fraternity, Dormitory, and Independent — compete in the following activities: Touch Football, Tennis, Golf, Bowling, Track, Cross Country, Ice Hockey, Speed Skating, Handball, Squash, Volleyball, Badminton, Water Basketball, Table Tennis, Six-Man Soccer, and Six-Man Lacrosse.

Recreation: The athletic facilities at L.T.I. are open for student use from 9:00 a.m. to 9:30 p.m. weekdays, and from 10:00 a.m. to 3:00 p.m. on Saturdays.

There are opportunities for student participation in the organized and informal recreational activities listed as follows: Badminton, Volleyball, Basketball, Physical Conditioning, Swimming, Diving, Water Basketball, Life Saving, Archery, Table Tennis, Touch Football, Skin and Scuba Diving, Wrestling, Judo, Karate, Rifle and Pistol Shooting, Weight Training, Gymnastics,

Handball, Squash, Tennis, Ice Skating, Track and Field, Softball, and Lacrosse.

Equipment needed for most of these sports is available from the Issue Room on presentation of the student's ID card.

Students are urged to supplement their required activities with a regular program of recreation.

PHYSICAL EDUCATION

Physical education makes its contribution to the total college curriculum through specific programs of conditioning exercises, self-testing activities, sports, recreational games, gymnastics, rhythms, aquatic activities, and personal defense activities such as wrestling, judo, and karate. Physical Fitness testing is included as a basic part of the program. The students are expected to become familiar with and develop efficiency in a variety of activities especially team games, individual recreational sports, swimming, and physical fitness.

The classes meet twice a week and are required for the Freshmen. Lowell Tech students must pass a swimming test and four quarters of Physical Education. Each quarter is half a semester. Students who satisfy minimum requirements in the swimming and the Physical Fitness Test are allowed to choose any activity which the Department offers. A new activity must be chosen each quarter.

Students who do not satisfy the minimum requirements are assigned a swimming or a Physical Fitness class. At the end of the quarter, these students are retested.

The program is elective for sophomores, juniors, and seniors. After completing the freshman requirement, they may choose those activities in which they wish to receive additional instruction. Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, physical education credit will be given for such participation.

The following objectives serve as guides for the entire program:

1. The improvement of health through increased organic vigor.
2. The development of efficient and effective sports-skills and motor fitness.
3. The development of desirable social attitudes and standards of conduct.
4. The development of an appreciation for an interest in physical activities which will result in continued participation in

wholesome and enjoyable leisure pursuits.

I INDIVIDUAL ACTIVITIES

P.E. 110	Physical Fitness
P.E. 112	Golf
P.E. 115	Individual Sports (handball-squash-paddle racquets)
P.E. 116	Tennis
P.E. 117	Archery
P.E. 120	Weight Training
P.E. 125	Gymnastics
P.E. 126	Badminton

II TEAM ACTIVITIES

P.E. 130	Basketball
P.E. 135	Hockey
P.E. 136	Skating
P.E. 140	Soccer
P.E. 145	Softball
P.E. 150	Touch Football
P.E. 155	Volleyball
P.E. 156	Indoor Team Games

III AQUATICS

P.E. 160	Swimming for Beginners
P.E. 161	Intermediate Swimming
P.E. 162	Pre Life-saving
P.E. 163	Life Saving
P.E. 164	Competitive Swimming
P.E. 165	Competitive Diving
P.E. 166	Water Basketball
P.E. 167	Water Polo
P.E. 168	Advanced Diving
P.E. 230	Scuba Club

IV COMBATITIVES

P.E. 170	Judo
P.E. 172	Karate
P.E. 175	Wrestling

V INTERCOLLEGIATE SPORTS

P.E. 400	Baseball
P.E. 405	Basketball
P.E. 470	Bowling
P.E. 200	Crew
P.E. 428	Cross Country
P.E. 410	Golf
P.E. 432	Gymnastics
P.E. 415	Hockey

P.E. 460	Lacrosse
P.E. 320	Riflery
P.E. 425	Soccer
P.E. 420	Skiing
P.E. 340	Squash
P.E. 465	Swimming
P.E. 430	Tennis
P.E. 320	Track
P.E. 435	Wrestling

UNDERGRADUATE PROGRAMS

Sixteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Biological Sciences	Mechanical Engineering
Business Administration	Meteorology
Chemical Engineering	Nuclear Engineering
Chemistry	Paper Engineering
Civil Engineering	Physics
Electrical Engineering	Plastics Technology
Industrial Management	Radiological Health Physics
Mathematics	Textile Engineering

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students.

A special curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering is open as an In-Service Training Program for employees of the Commonwealth of Massachusetts and its political subdivisions. Regulations for entrance into this program and subjects required prior to attending day classes as in-residence students are shown in the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

Four-year curricula leading to the degree of Bachelor of Science in Engineering Technology are in the process of being developed in most of the above fields of engineering. Announcements will be made when they become available.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and average number of hours in laboratory; after the parentheses, number indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory or 4 credits.

Some undergraduate subjects may be taken for graduate credit. Consult the Graduate School catalogue for details.

THE ELECTIVE SYSTEM

In all curricula an opportunity is given the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

Prior to the registration period for each semester, a list of the General Electives to be offered is made available to faculty and students. **To ensure fulfillment of degree requirements and accreditation standards, all General Elective choices must be approved by the Department Head or the Advisor in the curriculum in which the student is a degree candidate.**

Subjects taken in the United States Air Force ROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects taken in the junior and senior years in the ROTC program may be substituted for General Electives up to a maximum of 6 credits in all curricula **unless otherwise specified.** In most curricula this substitution can be made only in the senior year.

EC 302	Labor Economics	(3-0)3
EC 303	Microeconomic Theory	(3-0)3
EC 304	Macroeconomic Theory	(3-0)3
EC 402	Government and Business	(3-0)3
EC 403	International Trade Theory	(3-0)3
EC 404	Comparative Economic Systems	(3-0)3
EC 407	Econometrics	(3-0)3
EC 408	History of Economic Thought	(3-0)3
EC 410	Economic Development of Less Developed Countries	(3-0)3
EC 411	Public Finance	(3-0)3
EC 412	Managerial Economics	(3-0)3
EC 414	Engineering Economy	(3-0)3
LL 207	Oral Business Communication	(3-0)3
LL 209	Technical and Scientific Communication	(3-0)3
LL 213	Introduction to English Literature: to 1798	(3-0)3
LL 214	Introduction to American Literature:from 1865	(3-0)3
LL 215	Introduction to American Literature: to 1865	(3-0)3
LL 216	Introduction to English Literature: from 1798	(3-0)3
LL 218	Afro-American Literature	(3-0)3

LL 219	The Film in Communication		(3-0)3
LL 222	Educational Broadcasting Philosophy		(2-2)3
LL 233	Comparative Literature		(3-0)3
LL 234	Shakespeare		(3-0)3
LL 235	English Drama After Shakespeare		(3-0)3
LL 238	Science and Literature		(3-0)3
LL 259-260	Elementary German	(3-0)	(3-0)6
LL 261-262	Elementary Technical German	(3-0)	(3-0)6
LL 263-264	Elementary French	(3-0)	(3-0)6
LL 265-266	Elementary Russian	(3-0)	(3-0)6
LL 267-268	Elementary Spanish	(3-0)	(3-0)6
LL 309	Woman in Modern Fiction		(3-0)3
LL 311	Creative Writing and Advanced Composition		(3-0)3
LL 313	Introduction to Continental Literature		(3-0)3
LL 314	Continental Literature Since the Renaissance		(3-0)3
LL 315	Myth and Symbol in Literature		(3-0)3
LL 316	The English Bible as Literature		(3-0)3
LL 318	The Evolution of the Existential Hero		(3-0)3
LL 319-320	The Image of Man in Western Thought	(3-0)	(3-0)6
LL 333	Problems of Philosophy		(3-0)3
LL 335	The Southern Renaissance in American Literature		(3-0)3
LL 341	Satire		(3-0)3
LL 342	Utopian Literature		(3-0)0
LL 344	Modern American Poetry		(3-0)3
LL 345	Modern Irish Literature		(3-0)3
LL 363-364	Intermediate French	(3-0)	(3-0)6
LL 365-366	Intermediate Literary and Conversational Russian	(3-0)	(3-0)6
LL 367-368	Intermediate German	(3-0)	(3-0)6
LL 369-370	Intermediate Spanish	(3-0)	(3-0)6
LL 435	English Literature of the Eighteenth Century		(3-0)3
LL 436	English Romantic Poets		(3-0)3
LL 443	Science Fiction		(3-0)0
LL 444	Popular Culture		(3-0)3
LL 467	Seminar in German Masterpieces		(3-0)3
LL 471	The Modern American Novel		(3-0)3
LL 472	The Modern British Novel		(3-0)3
LL 473	World Drama		(3-0)3
LL 474	Modern Drama		(3-0)3
LL 476	Nineteenth-Century British Novel		(3-0)3
LL 481	Classical Literature		(3-0)3
LL 482	The Short Story		(3-0)3

LL 495-496	Reading and Research	(3-0) (3-0)6
LL 961	British Literature	(3-0)3
LL 962	American Literature	(3-0)3
SS 223	The United States: 1865-1917	(3-0)3
SS 224	The United States: 1918-1945	(3-0)3
SS 225	Europe: 1789-1914	(3-0)3
SS 226	Europe: 1914 to the Present	(3-0)3
SS 232	Social and Economic Change in Europe: 1750 to the Present	(3-0)3
SS 235	England: Roman Times to the Restoration	(3-0)3
SS 236	England: The Restoration to the Present	
SS 301	Government of the United States	(3-0)3
SS 303	Psychology	(3-0)3
SS 305	Sociology	(3-0)3
SS 307	Seminar in Sociology	(3-0)3
SS 308	Psychology of Interpersonal Behavior	(3-0)3
SS 322	Moral Problems in a Technological Age	(3-0)3
SS 340	The United States: 1945 to the Present	(3-0)3
SS 352	Contemporary Political Theory	(3-0)3
SS 362	Social Psychology	(3-0)3
SS 371	American Civilization to 1865	(3-0)3
SS 451	History of France	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	National Security Policy	(3-0)3
SS 474	Cultural Anthropology	(3-0)3
SS 478	Russia: The Soviet Union	(3-0)3
SS 482	The United States: Urban History	(3-0)3
SS 483	The Development of Western Civilization: to 1789	(3-0)3
SS 484	The Development of Western Civilization: Since 1789	(3-0)3
SS 485	Modern Governments of Europe	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-0)3
SS 489	Political Parties in the United States	(3-0)3
SS 494	England: The Empire Since 1793	(3-0)3
SS 495	The Technological Future: The Material Aspects	(3-0)3
SS 496	The Technological Future: The Social and Political Aspects	(3-0)3
SS 497	Tutorial: History or Political Science	(3-0)3
SS 501	Afro-American History	(3-0)3
SS 504	Technology and Social Change	(3-0)3
SS 505	Technology and Society	(3-0)3
SS 528	Social Ecology	(3-0)3

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration* or Industrial Management,** take the following subjects:

First Semester

CH	101	Chemical Principles	(4-0)3
CH	103	Chemical Principles Laboratory	(0-2)1
LL	111	English I	(3-0)3
MA	103	Calculus I	(3-0)3
PH	101	Physics	(4-1)4
		Total hours	(14-3)14

Second Semester

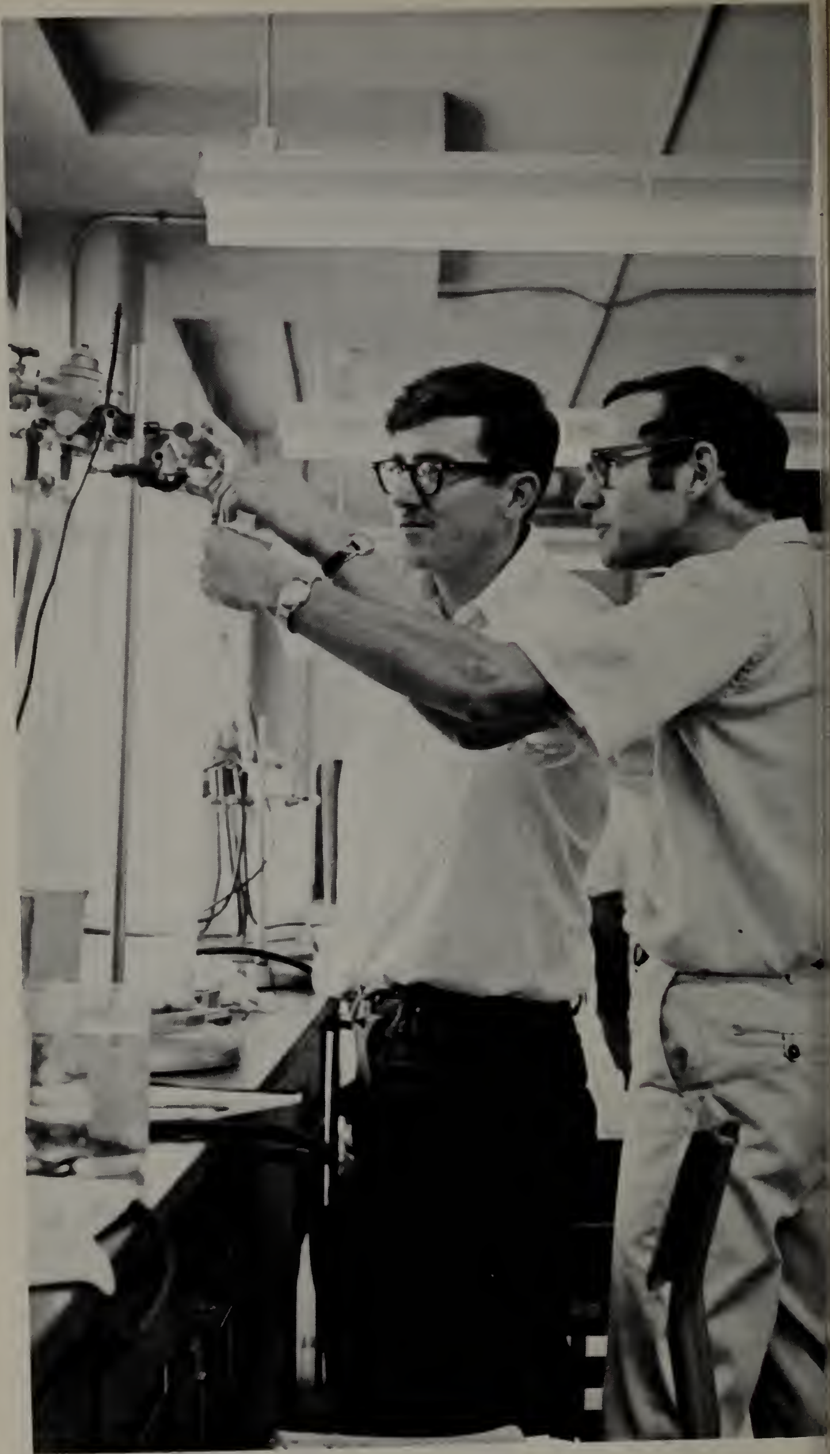
CH	102	Chemical Principles	(4-0)3
CH	104	Chemical Principles Laboratory	(0-2)1
LL	112	English II	(3-0)3
MA	104	Calculus II	(3-0)3
ME	104	Design Graphics	(1-0)1
PH	102	Physics	(4-2)4
		Total hours	(15-4)15

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given for the physical education program.

*The freshman program in Business Administration is given on the page outlining the curriculum.

**Majors in Industrial Management substitute EC 201, Economics 1(3-0)3, for CH 101 and CH 103, and EC 202, Economics II (3-0)3, for CH 102 and CH 104.

Students who elect to take the four-year AFROTC program must take the first two years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the junior and senior years may be substituted for other subjects. See the sections of the catalogue describing the individual curriculum, and the section on AFROTC for further details.



BIOLOGICAL SCIENCES

The Department was established in the fall of 1968 and is presently housed in temporary quarters which have been substantially increased. New facilities are expected to be completed for occupancy during the 1972-73 academic year. An area of 30,000 sq. ft. has been designed to include teaching laboratories, undergraduate research facilities, office-research modules and service areas such as animal quarters, rooms for instrumentation, preparation and temperature control as well as X-Ray, electron microscope and greenhouse facilities.

The curriculum in the Biological Sciences is designed to provide a sequence of liberal arts and science courses for a sound career foundation. Development of attitudes along with abilities is considered highly significant for a successful career. The importance of a breadth of knowledge and understanding of related scientific disciplines is stressed for greater appreciation and comprehension of biological principles and modern quantitative concepts.

Upon graduation the biology major will find opportunities in teaching, industry, government and the medical services. The curriculum objectives chosen permit a sound preparation for graduate study in the biological sciences, medicine and dentistry.

A written comprehensive examination is required of all majors. Students who have demonstrated high scholastic ability may conduct independent studies throughout the senior year. Emphasis is placed on completion of an original research project followed by an oral examination of the candidate's major courses and undergraduate thesis.

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(13-9)15

Second Semester

BI	202	Principles of Biology	(3-3)4
CH	222	Organic Chemistry	(3-4)4
MA	383	Statistical Methods	(3-0)3
		Two General Electives*	(6-0)6
		Total hours	(15-7)17

*LL 334 Problems of Philosophy and
SS 304 Psychology are recommended

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
BI	311	Microbiology	(3-3)4
CH	335	Principles of Physical Chemistry	(3-3)4
		Two General Electives	(6-0)6
		Total hours	(15-9)18

Second Semester

BI	306	Biochemistry	(3-3)4
BI	330	Ecology	(3-3)4
CH	336	Principles of Physical Chemistry	(3-3)4
		General Elective	(3-0)3
		Technical Elective* or General Elective	2 or 3
		Total credit hours	17 or 18

*BI 332 (Botany), BI 360 (Electron Microscopy), or MA 361 (Digital Computer Programming) recommended.

SENIOR YEAR

First Semester

BI	411	Research in Biology or Biology Elective	4
BI	451	Seminar in Biology	(1½-0)1
RS	441	Radioisotope Techniques	(3-3)4
		General Elective	(3-0)3
		Technical Elective	4
		Total credit hours	16

Second Semester

BI	412	Research in Biology or Biology Elective	4
BI	452	Seminar in Biology	(1½-0)1
BI	462	Radiation Biology	(3-0)3
		General Elective	(3-0)3
		Technical Elective	4
		Total credit hours	15

Not more than a total of six credits of junior or senior AS subjects may be substituted for technical or general electives.

BUSINESS ADMINISTRATION

The major objective of the curricula in Business Administration is to provide an undergraduate professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The common aspects of the curricula offer an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis is not technical but administrative. A common core of business and economic subjects — accounting, economics, finance, business law, marketing, production, statistics — is required of all students. An extensive selection of courses in languages and literature, the social sciences, and mathematics, broadens each student's intellectual capacity.

After a common freshman year each student is required to select a major area of study. These are: accounting, economics, and management. The management area ia further subdivided into financial management, marketing management, and production management.

FRESHMAN YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	191	Physical Science I	(3-0)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	141	Accounting II	(3-0)3
BA	192	Physical Science II	(3-0)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis I	(3-0)3
		Total hours	(15-0)15

All nonveteran male students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given.

ELECTIVE COURSE GUIDELINES FOR ALL BA OPTIONS

Behavioral Science: The student may select any SS courses in Psychology and/or Sociology.

General Electives: Where a General Elective is indicated a

student may select any course bearing an EC, LL, or SS prefix not required in his curriculum. If the student is in the advanced Air Force R.O.T.C. program he will substitute AS 301, 302, 401, and 402, for the General Electives normally taken in the junior and senior years.

Management: Students choosing the Management Option will select an area of concentration (Finance, Marketing, or Production). Those choosing Finance must take BA 334 and BA 431 plus two other courses acceptable to their Faculty Advisor as concentration electives. Those choosing Marketing must take BA 326 and BA 423 plus two other marketing courses acceptable to their Faculty Advisor. Those choosing Production must take IM 371 and IM 483 plus two other courses acceptable to their Faculty Advisor as concentration electives. Production majors must also substitute Cost Accounting BA 344 for Managerial Accounting BA 346 in the junior year and Advanced Cost Accounting BA 444 for a BA elective in the senior year. For all areas of concentration, the four courses selected must be over and above the Finance, Marketing, and Production courses required of all students.

ACCOUNTING OPTION
SOPHOMORE YEAR

First Semester

BA	241	Accounting III	(3-0)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		LL Elective	3
		Total credit hours	15

Second Semester

BA	242	Accounting IV	(3-0)3
EC	212	Economic Statistics II	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	(3-0)3
		LL Elective	3
		Total credit hours	15

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	341	Accounting V	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Principles	(3-0)3
		BA Elective	3
		General Elective	3
		Total credit hours	18

Second Semester

BA	331	Business Finance	(3-0)3
BA	342	Accounting VI	(3-0)3
BA	344	Cost Accounting	(3-0)3
BA	363	Advanced Business Law	(3-0)3
BA	403	Electronic Data Processing	(3-0)3
		General Elective	3
		Total credit hours	18

SENIOR YEAR

First Semester

BA	441	Auditing	(3-0)3
BA	444	Advanced Cost Accounting	(3-0)3
BA	451	Personnel Management	(3-0)3
		BA or EC Elective	3
		General Elective	3
		Total credit hours	15

Second Semester

BA	445	Tax Accounting	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
		General Elective	3
		BA or EC Elective	3
		Total credit hours	15

ECONOMICS OPTION
SOPHOMORE YEAR

First Semester

EC	211	Economic Statistics I	(3-0)3
EC	301	American Economic History	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
LL	311	Advanced Composition	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	331	Business Finance	(3-0)3
BA	346	Managerial Accounting	(3-0)3
EC	212	Economics Statistics II	(3-0)3
EC	304	Macroeconomic Theory	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Total hours	(15-0)15

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
EC	311	Mathematics for Economists	(3-0)3
LL	333	Problems of Philosophy	(3-0)3
		Behavioral Science Elective	3
		Total credit hours	18

Second Semester

BA	371	Production Principles	(3-0)3
EC	407	Econometrics	(3-0)3
		or	
		EC Elective	3
EC	408	History of Economic Thought	(3-0)3
SS	301	Government of the United States	(3-0)3
		BA Elective	3
		Behavioral Science Elective	3
		Total credit hours	18

SENIOR YEAR

First Semester

BA	403	Electronic Data Processing	(3-0)3
EC	402	Government and Business	(3-0)3
		BA Elective	3
		EC Elective	3
		General Elective	3
		Total credit hours	15

Second Semester

EC	404	Comparative Economic Systems	(3-0)3
EC	412	Managerial Economics	(3-0)3
		BA Elective	3
		EC Elective	3
		General Elective	3
		Total credit hours	15

MANAGEMENT OPTION
SOPHOMORE YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Behavioral Science Elective	3
		LL Elective	3
		Total credit hours	15

Second Semester

BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	3
		LL Elective	3
		Total credit hours	15

JUNIOR YEAR

First Semester

BA	331	Business Finance	(3-0)3
BA	362	Business Law	(3-0)3
BA	403	Electronic Data Processing	(3-0)3
		Concentration Elective	3
		General Elective	3
		BA or EC Elective	3
		Total credit hours	18

Second Semester

BA	332	Money and Banking	(3-0)3
BA	346	Managerial Accounting*	(3-0)3
EC	402	Government and Business	(3-0)3
		Concentration Elective	3
		BA or EC Elective	3
		General Elective	3
		Total credit hours	18

*Production majors take BA 344 — Cost Accounting

SENIOR YEAR

First Semester

BA	453	Organizational Behavior	(3-0)3
BA	471	Analytical Methods in Management	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Concentration Elective*	3
		General Elective	3
		Total credit hours	15

*Production majors take BA 444
— Advanced Cost Accounting

Second Semester

BA	498	Business Policy	(3-0)3
		Concentration Elective	3
		General Elective	3
		BA or EC Electives	6
		Total credit hours	15

CHEMICAL ENGINEERING

Chemical Engineering is the only engineering discipline based on the science of chemistry, although it is broadly rooted in the other scientific disciplines as well. It combines elements of most of the other engineering disciplines and applies chemistry and engineering to industrial problems through the concepts of unit operations and unit processes.

The chemical process industries have provided a strong and continued growth with an ever-increasing demand for chemical engineering graduates. Current shortages of chemical engineers are expected to persist for many years to come, leading to substantial increases both in opportunities and in financial rewards. The stability and dynamic growth of the chemical and allied industries opens up unparalleled challenges and growth prospects to the chemical engineer. The broad chemical and engineering training provided in this curriculum offers the graduate opportunities to enter Research and Development, Production, Sales, Marketing and General Management. It also gives him the tools to develop a career both stimulating and satisfying.

The student obtains a strong scientific background in the first two years, followed by two years of training in the discipline and related subjects. The curriculum provides maximum flexibility and allows for individual and original research if the student wishes. By taking several extra courses, it is possible to obtain a degree in Paper Engineering as well as Chemical Engineering. Considerable emphasis is placed on oral and written expression so necessary in the business world. Plant trips provide the essential link between theory and practice. Summer experience in the chemical industry is fostered. The student can enter either industry or graduate school upon graduation.

SOPHOMORE YEAR

First Semester

CH	223	Organic Chemistry	(3-0)3
CN	203	Introduction to Chem. Eng.	(3-0)4
CN	209	Introduction to the Chemical Industry	(3-0)3
MA	203	Calculus III	(3-0)3
MA	360	Digital Computer Programming	(2-0)2
ME	215	Analytic Mechanics I	(3-0)3
		Total hours	(17-3)18

Second Semester

CH	224	Organic Chemistry	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-0)2
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-3)18

JUNIOR YEAR

First Semester

CN	301	Mathematics for Chemical Engineers	(3-0)3
CN	305	Transport Phenomena I	(3-0)3
CN	311	Chemical Engineering Thermodynamics I	(3-0)3
CN	315	Unit Operations Laboratory I	(0-3)1
EE	348	Electrical Engineering Concepts	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

Second Semester

CH	336	Physical Chemistry	(3-3)4
CN	306	Transport Phenomena II	(3-0)3
CN	310	Separation Processes	(3-0)3
CN	312	Chem. Eng. Thermodynamics II	(3-0)3
CN	316	Unit Operations Laboratory II	(0-3)1
		General Elective	(3-0)3
		Total hours	(15-6)17

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	409	Economic Process Analysis	(3-0)3
CN	416	Profession Orientation	(1-0)1
		General Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(16-0)16

Second Semester

CN	408	Material Science	(3-0)3
CN	410	Plant Design	(3-0)3
CN	414	Process Dynamics and Control	(3-0)3
		General Electives	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(15-0)15

CHEMISTRY

The curriculum is Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

SOPHOMORE YEAR

First Semester

CH	207	Inorganic Chemistry	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
PH	201	Physics	(4-2)4
		Total hours	(15-9)17

Second Semester

CH	210	Analytical Chemistry I	(3-4)4
CH	222	Organic Chemistry	(3-4)4
CH	232	Physical Chemistry	(3-3)4
MA	204	Calculus IV	(3-0)3
		Total hours	(12-11)15

JUNIOR YEAR

First Semester

CH	311	Analytical Chemistry II	(3-4)4
CH	333	Physical Chemistry	(3-3)4
LL	261	Elementary Technical German	(3-0)3
		Two General Electives	(6-0)6
		Total hours	(15-7)17

Second Semester

CH	442	Advanced Inorganic Chemistry I	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		Chemistry Elective	3 or 4
		Two General Electives	(6-0)6
		Total credit hours	15 or 16

SENIOR YEAR

First Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

Second Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

The Technical Electives in the Junior and Senior years must include chemistry subjects which will provide a minimum of 60 contact hours of laboratory instruction. Recommended laboratory electives include CH 321, CH 342, CH 403 and 404, CH 407 and 408 and CH 481 and 482. If Undergraduate Thesis is elected, both semesters must be taken, and one additional laboratory subject must also be taken to provide an approved program.

The General Electives in the Junior and Senior years must include a minimum of 18 credits in Humanities and Social Studies not including elementary foreign language, composition, or communication subjects.

A student electing Air Force ROTC in the Junior and Senior years may substitute a maximum of six credits of required General or Technical Electives by AS subjects. It is recommended that this substitution be made in the Senior year.

CIVIL ENGINEERING

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and processing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes; and the adaptation of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are Civil Engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

SOPHOMORE YEAR

First Semester

CE	201	Surveying I	(3-4)4
EC	201	Economics I	(3-0)3
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(18-6)19

Second Semester

CE	202	Surveying II	(3-4)4
EC	202	Economics II	(3-0)3
MA	204	Calculus IV	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
PH	202	Physics	(4-2)4
		Total hours	(16-6)17

JUNIOR YEAR

First Semester

CE	311	Engineering Materials	(2-3)3
EE	211	Fundamentals of Electricity	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
MA	362	Numerical Analysis	(3-0)3
ME	309	Dynamics I	(3-0)3
ME	347	Elements of Thermodynamics & Heat Transfer	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-6)19

Second Semester

CE	312	Structures I	(3-0)3
CE	322	Hydraulics	(4-0)4
CE	342	Transportation	(3-3)4
EE	212	Introductory Electronics	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-3)17

SENIOR YEAR

First Semester

CE	411	Structures II	(3-3)4
CE	413	Concrete	(3-3)4
CE	421	Hydrology	(3-3)4
CE	431	Soil Mechanics I	(3-0)3
		General or Techanical Elective*	(3-0)3
		Total hours	(15-9)18

*ROTC students may substitute AS 401

Second Semester

CE	412	Structures III	(3-3)4
CE	432	Soil Mechanics II	(3-3)4
EC	414	Engineering Economy	(3-0)3
LL	210	Technical and Scientific Communication	(3-0)3
		General or Technical Elective*	(3-0)3
		Total hours	(15-6)17

*ROTC students may substitute AS 402

CIVIL ENGINEERING TECHNOLOGY

The following curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering Technology is available only to employees of the Commonwealth of Massachusetts and its political subdivisions as an In-Service Training Program. For regulations concerning this program and for subjects required prior to the following curriculum, consult the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

This curriculum is accredited by the Engineers' Council for Professional Development.

JUNIOR YEAR

Second Semester

CE	361	Advanced Surveying	(2-1)2
CE	971	Structures	(2-1)2
DP	930	Scientific Computer Programming — FORTRAN	(2-1)2
LL	962	American Literature	(3-0)3
PH	942	Physics	(3-2)4
		General Elective	(3-0)3
		Total hours	(15-5)16

SENIOR YEAR

First Semester

CE	991	Concrete Analysis and Design	(3-3)4
CE	992	Soil Mechanics	(3-3)4
CE	995	Engineering Laboratory	(0-3)1
EE	975	Basic Electricity	(3-3)4
		General Elective	(3-0)3
		Total hours	(12-12)16

Second Semester

CE	981	Structural Analysis & Design	(3-3)4
CE	982	Hydrology	(3-3)4
CE	994	Engineering Problems	(2-1)2
EC	414	Engineering Economy	(3-0)3
EE	978	Basic Electronics	(3-0)3
		Total hours	(14-7)16

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering. This curriculum is accredited by the Engineers' Council for Professional Development.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classrooms. Specialization at the undergraduate level is, in general, discouraged. The student wishing to specialize in a specific area of electrical engineering may, with special permission, modify the order of the required courses, provided all prerequisites are met, in order that he may enroll in a sequence of technical electives in his area of specialty. All of the required courses must be successfully completed however before the student can be recommended for graduation.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

Many of the courses required in the Electrical Engineering curriculum are heavily dependent upon rather sophisticated mathematical techniques. It is therefore recommended that a freshman seeking admission into the sophomore year of Electrical Engineering should have received grades of not less than C— in all freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory I	(4-0)4
EE	207	Basic Electrical Engineering Laboratory I	(1-3)2
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory II	(4-0)4
EE	208	Basic Electrical Engineering Laboratory II	(1-3)2
MA	204	Calculus IV	(3-0)3
ME	212	Mechanics and Properties of Matter	(4-0)4
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EE	311	Electronics Laboratory I	(1-3)2
EE	319	Electronics I	(4-0)4
EE	327	Programming and Application of Digital Computers I	(2-0)2
EE	355	Introductory Electromechanics	(3-0)3
MA	315	Complex Variables for Engineers	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-3)17

Second Semester

EE	312	Electronics Laboratory II	(1-3)2
EE	320	Electronics II	(4-0)4
EE	328	Programming and Application of Digital Computers II	(2-0)2
EE	360	Electromagnetic Theory I	(3-0)3
EE	362	Signal and System Analysis	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-3)17

SENIOR YEAR

First Semester

EE	461	Electromagnetic Theory II	(3-0)3
EE	413	Linear Feedback Systems	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		General or Technical Electives*	4
		Technical Elective	3
		Total credit hours	16

*ROTC students may substitute AS 401 for three hours.

Second Semester

		General Elective	(3-0)3
		General or Technical Electives*	12
		Total credit hours	15

*ROTC students may substitute AS 402 for three hours.

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide a student with a sound foundation in the pure sciences and mathematics, in the humanities, and in the social sciences. In addition, the core subjects of management — accounting, finance, marketing and production — are required. All students also take a selection of engineering and management courses to prepare them to handle the tasks they will have in industry after graduation. Some specialization is provided in the junior and senior years under guidance of a Faculty Advisor.

SOPHOMORE YEAR

First Semester

BA	143	Accounting Management I	(3-0)3
CH	101	Chemical Principles	(4-0)3
CH	103	Chemical Principles Laboratory	(0-2)1
MA	203	Calculus III	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
PH	201	Physics	(4-2)4
		Total hours	(15-7)16

Second Semester

BA	144	Accounting Management II	(3-0)3
CH	102	Chemical Principles	(4-0)3
CH	104	Chemical Principles Laboratory	(0-2)1
EC	211	Economic Statistics I	(3-0)3
LL	210	Technical & Scientific Communication	(3-0)3
MA	204	Calculus IV	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-3)3
BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
		Total hours	(17-0)17

Second Semester

BA	403	Electronic Data Processing	(3-0)3
IM	372	Production Problems	(3-0)3
IM	483	Statistical Quality Control	(3-0)3
ME	372	Strength of Materials	(3-0)3
		General Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

BA	404	Computer Applications to Management	(3-0)3
BA	451	Personnel Management	(3-0)3
EE	351	Industrial Electronics	(3-0)3
MA	381	Operations Research	(3-0)3
		General Elective	3
		BA or EC Elective*	3
		Total credit hours	18

*ROTC students may substitute AS 401.

Second Semester

EC	412	Managerial Economics	(3-0)3
MA	382	Operations Research	(3-0)3
ME	344	Heat and Power	3
		General Elective	3
		BA or EC Elective*	3
		Total credit hours	15

*ROTC students may substitute AS 402.

MATHEMATICS

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics — algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

The approaches to these objectives are also twofold, viz., by way of course work and supervised project activity. In order to achieve breadth, each of the major areas mentioned above is represented by at least one required three-hour subject. A deeper study of one or more areas is provided by the student's elective program, subject to the approval of his departmental advisor.

The purpose of the project work is to enable the student to "read, write, and speak" mathematics via the reading of simple journal articles, the preparation of short papers, and oral presentations. This aspect of the program is regarded as at least as important as the formal course work. Participation in a working seminar is required of all mathematics majors during the senior year.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields of teaching and industry.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MA	221	Linear Algebra	(3-0)3
PH	201	Physics	(4-2)4
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

MA	204	Calculus IV	(3-0)3
MA	222	Linear Algebra	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-0)17

JUNIOR YEAR

First Semester

MA	305	Introduction to Real Analysis	(3-0)3
MA	321	Modern Algebra	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

MA	306	Introduction to Real Analysis	(3-0)3
MA	334	Projective Geometry	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

**To be selected from an approved department list.

SENIOR YEAR

First Semester

MA	411	Complex Variables	(3-0)3
		Mathematics Elective**	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 401
**To be selected from an approved departmental list

Second Semester

MA	498	Mathematics Seminar	(3-0)3
		Mathematics Elective**	(3-0)3
		Mathematics Elective**	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 402
**To be selected from an approved departmental list

MECHANICAL ENGINEERING

Mechanical Engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and automatic controls (electricity, electronics, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, technical electives are provided in the senior year. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	206	Mechanical Engineering Laboratory I	(0-3)1
ME	220	Mechanics of Materials I	(3-0)3
ME	242	Thermodynamics	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-3)18

JUNIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
MA	301	Advanced Calculus for Applications	(3-0)3
ME	307	Mechanical Engineering Laboratory II	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	382	Fluid Mechanics I	
ME	395	Materials Science	(3-0)3
		Total hours	(15-3)16

Second Semester

EC	202	Economics II	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
ME	308	Mechanical Engineering Laboratory III	(0-3)1
ME	320	Machine Design I	
ME	343	Heat Transfer	(3-0)3
ME	354	Dynamic Systems	(3-0)3
		Total hours	(14-6)16

SENIOR YEAR

First Semester

ME	407	Mechanical Engineering Laboratory IV	
ME	413	Gas Dynamics	(3-0)3
ME	417	Dynamics II	(3-0)3
ME	453	Senior Project I	(0-3)1
ME	497	Automatic Control Systems	(3-0)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	17

*ROTC students may substitute AS 401

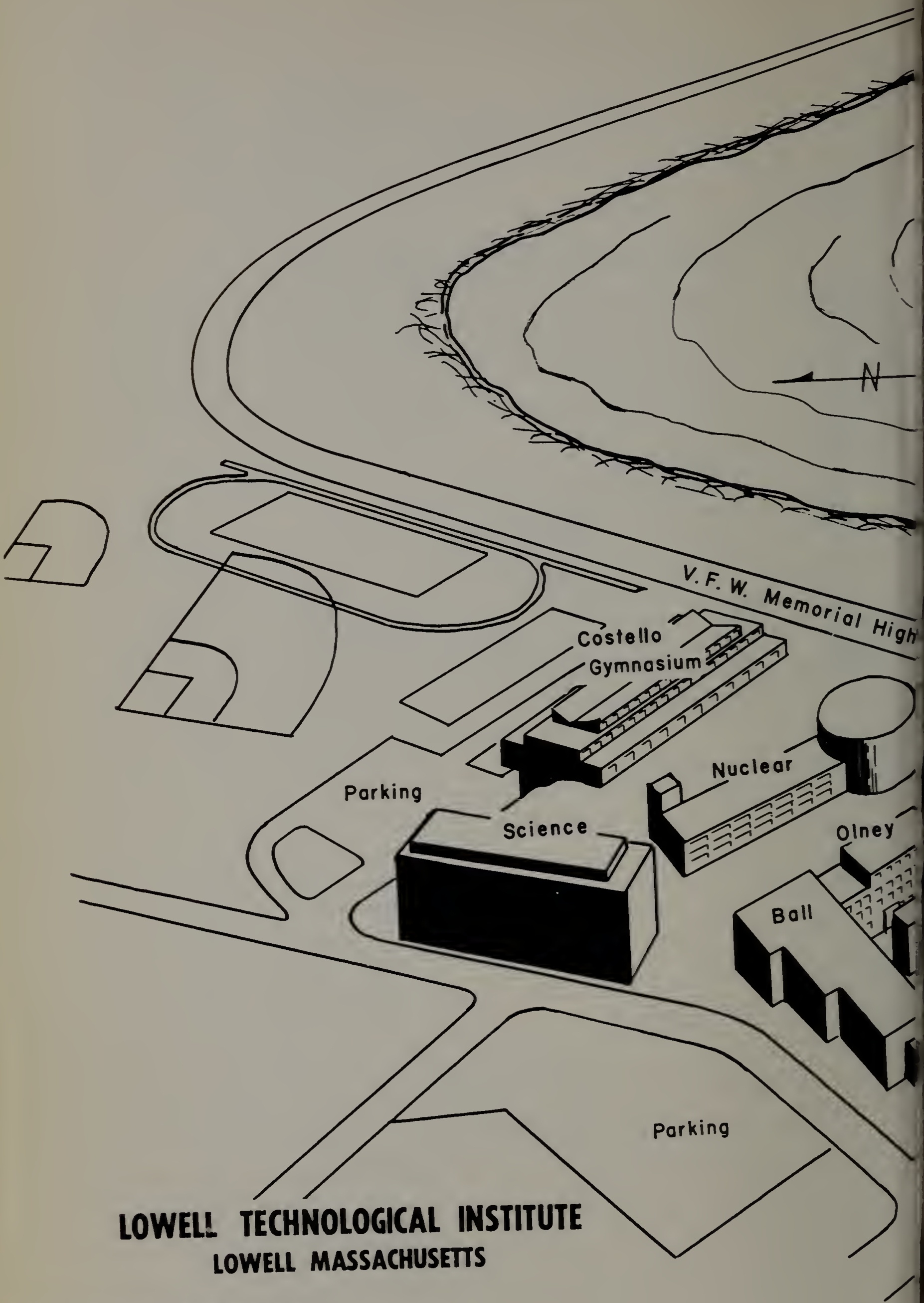
Second Semester

ME	454	Senior Project II	(0-6)2
		Technical Elective	3
		Technical Elective	3
		General Elective	3
		General or Technical Elective	3
		General or Technical Elective*	3
		Total credit hours	17

*ROTC students may substitute AS 402.

APPROVED TECHNICAL ELECTIVES

EE	353	Electrical Controls and Power Circuits	(3-0)3
MA	452	Application of Numerical Analysis	(3-0)3
ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	422	Machine Design II	(2-3)3
ME	428	Kinematic Mechanism Synthesis	(3-0)3
ME	462	Engineering Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	473	Mechanics of Materials II	(3-0)3
ME	474	Thermodynamic Applications	(3-0)3
ME	475	Physical Metallurgy	(3-0)3
ME	477	Composite Materials	(3-0)3
ME	480	Advanced Projects in Systems and Design	(1-6)3
ME	488	Environmental Conditioning	(3-0)3
ME	500	Series subjects open to undergraduate by Department approval	

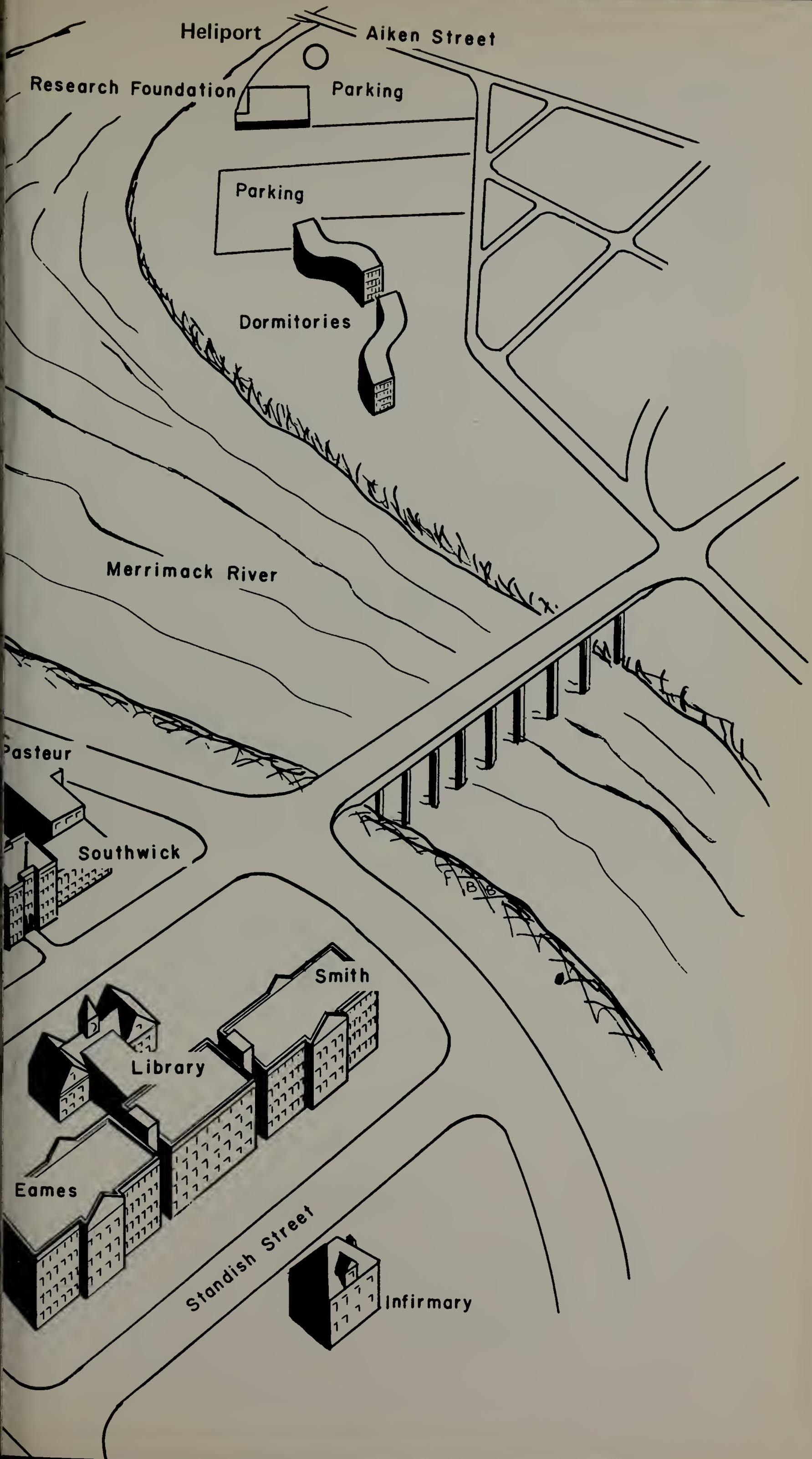


LOWELL TECHNOLOGICAL INSTITUTE

LOWELL MASSACHUSETTS

CLASSROOM DESIGNATION:

LETTER PREFIX REFERS TO BUILDING
FIRST NUMBER INDICATES FLOOR
HENCE, ROOM K-311 IS LOCATED IN KITSON HALL, 3rd FLOOR


Heliport
Aiken Street
Research Foundation
Parking
Parking
Dormitories
Merrimack River
Pasteur
Southwick
Smith
Library
Eames
Standish Street
Infirmary

METEOROLOGY

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of the other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of tomorrow's weather for the general public to the analysis of the influence of weather and climate on particular operations in agriculture, engineering, industry and commerce, national defense and public health. Meteorologists are employed in these capacities by the agencies of the Environmental Science Services Administration, especially the Weather Bureau, by agencies of the Defense Department and by commercial aviation companies and private consulting firms. Meteorological research conducted by agencies of the U.S. Government, universities and private research companies is becoming increasingly important as a field of employment. Although graduate training is essential for advancement in this field, the U.S. Government and most private employers provide opportunities for individuals to acquire this training. The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MY	205	Elementary Meteorology	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	16

Second Semester

MA	204	Calculus IV	(3-0)
MY	206	Elementary Meteorology	(3-0)
PH	202	Physics	(4-2)
		General Elective	(3-0)
		Technical Elective	
		Total credit hours	1

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
MY	301	Atmospheric Dynamics	(3-0)3
MY	308	Synoptic Meteorology	(2-3)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
MY	302	Atmospheric Dynamics	(3-0)3
MY	307	Tropical Meteorology	(3-0)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

MY	403	Physical Meteorology	(3-0)3
MY	415	Advanced Atmospheric Dynamics	(3-0)3
MY	421	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may substitute AS 401.

Second Semester

MY	413	Oceanography	(3-0)3
MY	416	Advanced Atmospheric Dynamics	(3-0)3
MY	422	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may substitute AS 402.

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

Six general electives are required and can be selected from the elective system with the exception of LL 261-262, LL 365-366 and EC 301 thru EC 414.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	242	Thermodynamics	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-4)16

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
MA	302	Advanced Calculus for Applications	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(13-7)16

SENIOR YEAR

First Semester

ME	382	Fluid Mechanics I	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	497	Computer Programming and Applications	(3-2)3
RS	401	Principles of Radiation Safety & Control*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-2)15

*ROTC students may substitute AS 401

Second Semester

ME	443	Heat Transfer	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
NU	498*	Computer Programming and Applications	(3-2)3
		General Elective	(3-0)3
		Total hours	(12-8)15

*ROTC students may substitute AS 402. A technical elective with 3 credits may also be substituted for this course.

APPROVED TECHNICAL ELECTIVES

EE	446	Digital Devices and Techniques	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3
NU	495	Special Nuclear Problems	(3-0)3

PAPER ENGINEERING

Paper Engineering is an engineering discipline, strongly based in Chemical Engineering but with major emphasis on the technical aspects of the Paper Industry. The Paper Engineer is thus able to enter not only the Chemical Process Industries but the Paper Industry as well.

The Paper Industry is the fifth largest industry in the United States. By virtue of satisfying basic human needs and its broad spectrum of products, it provides both dynamic growth and stability. The products of the Paper Industry and its sister industries are integral to every aspect of human life and endeavor.

Because of the increasing complexity of pulp and paper operations and of the converting industry, there is an intense and growing demand for well-trained engineers in all aspects of the business. The converting industry particularly involves not only paper but plastics, chemicals, metals and other materials as well. Engineers trained for this group of industries must not only have a fundamental scientific training but a broad background of practical problem solving as well.

The Paper Engineering Curriculum is basically Chemical ngineering with a minor in Paper Engineering. In fact, the two egrees may be obtained by taking extra courses in Chemical ngineering. Emphasis is placed on an engineering analysis of ne Paper Industry, its production methods, economics, fundaental properties of its raw materials and the Unit Operations ivolved in manufacturing. The graduates of Paper Engineering nay go either directly into industry or may continue on to gradate studies. In the paper and allied industries they find themelves in positions in Research and Development, Producting, ales, or Marketing, Sales Service and frequently in General lanagement.

Paper Engineers who maintain a 2.00 cumulative rating are igible for scholarships with a $500 annual stipend.

SOPHOMORE YEAR

First Semester

H	223	Organic Chemistry	(3-0)3
N	203	Introduction to Chem. Eng.	(3-3)4
N	209	Introduction to the Chemical Industry	(3-0)3
A	203	Calculus III	(3-0)3
A	360	Digital Computer Programming	(2-0)2
E	215	Analytic Mechanics I	(3-0)3
		Total hours	(17-3)18

Second Semester

CH	224	Organic Chemistry	(3-3)4
CN	204	Chemical Enginering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-0)2
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-3)18

JUNIOR YEAR

First Semester

CN	301	Mathematics for Chemical Engineers	(3-0)3
CN	305	Transport Phenomena I	(3-0)3
CN	311	Chemical Engineering Thermodynamics I	(3-0)3
CN	315	Unit Operations Laboratory I	(0-3)1
PA	301	Engineering Analysis of Pulp Systems	(3-0)3
PA	307	Physical Testing and Data Analysis	(2-3)3
		Total hours	(14-6)16

Second Semester

CH	336	Physical Chemistry	(3-3)4
CN	306	Transport Phenomena II	(3-0)3
CN	310	Separation Processes	(3-0)3
CN	316	Unit Operations Laboratory II	(0-3)1
PA	302	Engineering Analysis of Paper Systems	(3-3)4
		General Elective	(3-0)3
		Total hours	(15-9)18

SENIOR YEAR

First Semester

CN	416	Profession Orientation	(1-0)1
EE	348	Electrical Engineering Concepts	(3-0)3
PA	403	Engineering Analysis of Converting	(3-0)3
PA	405	Paper Converting Laboratory I	(0-3)1
		General Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(16-3)17

Second Semester

CN	414	Process Dynamics and Control	(3-0)3
PA	406	Pulp and Paper Systems Calculations	(2-0)2
PA	408	Paper Converting Laboratory II	(0-3)1
		General Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(14-3)15

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

SOPHOMORE YEAR

First Semester

PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	209	Physics	(4-0)4
PH	293	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(13-6)15

Second Semester

PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	210	Physics	(4-0)4
PH	294	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(13-6)15

JUNIOR YEAR

First Semester

PH	311	Intermediate Mechanics	(3-0)3
PH	335	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	393	Advanced Laboratory	(0-6)2
		General or Technical Elective	(3-0)3
		Total hours	(12-6)14

Second Semester

PH	312	Intermediate Mechanics	(3-0)3
PH	336	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	394	Advanced Laboratory	(0-6)2
		General or Technical Elective	(3-0)3
		Total Hours	(12-6)14

SENIOR YEAR

First Semester

PH	423	Thermodynamics	(3-0)3
		General or Technical Elective	(3-0)3
		General or Technical Elective	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 401.

Second Semester

PH	424	Introduction to Statistical Mechanics	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students may substitute AS 402.

TECHNICAL ELECTIVES

PH	441-441	Introduction to Relativity and Quantum Mechanics	(3-0) (3-0)6
PH	461-462	Nuclear Physics	(3-0) (3-0)6
PH	471-472	Solid State Physics	(3-0) (3-0)6
PH	495-496	Special Research Problems	(3-0) (3-0)6
PH	505-506	Mathematical Methods of Physics	(3-0) (3-0)6
PH	511-512	Classical Mechanics	(3-0) (3-0)6
MA	411	Complex Variables I	(3-0)3
MA	434	Matrix Algebra	(3-0)3
MA	484	Probabilities	(3-0)3
MA	542	Fourier Series and Boundary Value Problems	(3-0)3
MA	575	Operational Mathematics	(3-0)3

All physics majors must take no less than six and no more than ten General Electives. In addition to the approved technical electives, any course offered by the Institute, and which is approved by the Student Advisor may be taken as technical elective.

In addition, two must be in some foreign language usually French, German, or Russian.

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry, strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics and quality control augment the basic courses in mathematics, sciences and engineering to round out a well-balanced program in Plastics Technology.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the international Society of Plastics Engineers, an opportunity which affords every student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry I	(3-3)4
MA	203	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
PH	201	Physics III	(4-2)4
PL	201	Introduction to Polymeric Materials	(2-2)3
		Total credit hours	(15-7)17

Second Semester

CH	224	Introductory Organic Chemistry II	(3-3)4
ME	216	Analytic Mechanics II	(3-0)3
L	210	Technical and Scientific Communication	(3-0)3
L	202	Introduction to Polymeric Materials	(2-2)3
L	204	Process Control Systems	(3-0)3
		Total credit hours	(14-5)16

JUNIOR YEAR

First Semester

H	335	Principles of Physical Chemistry	(3-3)4
C	201	Economics I	(3-0)3
IE	373	Plastics Mold and Die Design	(2-2)3
L	301	Plastics Technology I	(2-2)3
		General Elective	3
		Total credit hours	16

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
EC	202	Economics II	(3-0)3
ME	376	Plastics Mold Design and Construction (Optional)	(0-3)1
PL	302	Plastics Technology II	(2-2)3
		General Elective	3
		General or Technical Elective	3
		Total credit hours	16 or 17

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
PL	401	Plastics Technology III	(2-0)2
PL	403	Physical Properties of Polymers	(2-2)3
PL	405	Methods of Polymer Characterization	(2-0)2
PL	411	Plastics Seminar	(1-0)1
PL	413	Senior Projects I	(0-2)1
		General or Technical Elective	3
		Total credit hours	16

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
PL	402	Plastics Technology IV	(2-0)2
PL	404	Physical Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
PL	414	Senior Projects II	(0-2)1
		General or Technical Elective	3
		General Elective	3
		Total credit hours	17

General Electives

Humanities — 9 credits required.

Recommended Technical Electives

ME	271	Machine Tool Laboratory	(1-3)2
ME	296	Material Science	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
PL	406	Polymer Structure	(3-0)3
PL	407	Plastics Industry Organization	(3-0)3

RADIOLOGICAL HEALTH PHYSICS

The Radiological Health Physics Program offered by the Department of Radiological Sciences is designed to provide needed professional personnel to help advance the safe utilization of nuclear energy and radiation. It is conducted through the cooperation of other departments and provides the best education and experience within the practical limitations imposed by time and resources to carefully selected and highly motivated students. The program is supported by the Bureau of Radiological Health, Environmental Control Administration, Department of Health, Education and Welfare. The program includes specialized training and education during the summer months, summer internship programs, and scholarships for qualified students.

The academic program is broad based in the basic sciences so that students will be able to recognize and appreciate the many complex and interrelating factors in the solution of problems facing the nuclear industry.

Students will benefit from cooperative summer training programs utilizing the radiation facilities and staff of the LTI Nuclear Center, government laboratories, industries, and major hospitals. This training and education in the nuclear sciences and radiological health gives experience with equipment and methods characteristic of current techniques and philosophy of professional practice in the radiation protection field. The summer program enables students to better select a professional position after graduation and better equips them for the pursuit of advanced degrees and research in the field.

Summer

RS	100	Basic Radiological Health Physics	8 weeks

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
E	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
H	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-5)17

Second Semester

I	202	Principles of Biology	(3-3)4
E	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
H	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-5)17

Summer

RS	200	Applied Radiological Health Physics	8 weeks work experience

JUNIOR YEAR

First Semester

LL	209	Technical and Scientific Communication	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	363	Introductory Nuclear Physics	(3-0)3
RS	401	Principles of Radiation Safety and Control	(3-0)3
		Total hours	(15-4)17

Second Semester

BI	462	Radiation Biology	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	366	Intermediate Nuclear Physics	(3-0)3
RS	402	Principles of Radiation Safety and Control	(3-3)4
		Total hours	(15-7)18

Summer

RS	300	Applied Radiological Health Physics	8 weeks work experience

SENIOR YEAR

First Semester

RS	411	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	431	Seminar in Radiological Sciences	(2-0)1
RS	451	Introduction to Electronic Product Radiation	(3-0)3
		General Elective*	(3-0)3
		General Elective	(3-0)3
		General Elective	(3-0)3
		Total credit hours	15, 16 or 17

*ROTC students may substitute AS 401

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
RS	412	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	432	Seminar in Radiological Sciences	(2-0)1
RS	452	Electronic Product Radiation Laboratory	(1-4)3
		General Elective*	(3-0)3
		General Elective	(3-0)3
		Total credit hours	15, 16 or 17

*ROTC students may substitute AS 402

Summer

RS	500	Post Graduate Radiological Health	10 week practicum

APPROVED TECHNICAL ELECTIVES

MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3
RS	501	Radiation Physics and Shielding Design	(3-0)3
RS	503	Introduction to Radiation Chemistry	(3-0)3

TEXTILE ENGINEERING

The object of this curriculum in Textile Engineering is to provide the student with a firm understanding of scientific principles and their application to the textile industry and its related branches.

During the first two years the student is thoroughly instructed in basic mathematics, physics, and chemistry. This fundamental work is followed by more specialized training in the field of Textiles and related areas of Mechanical Engineering.

A wide range of laboratory work is included in the curriculum in order to demonstrate both the use of the experimental method in the solution of engineering problems and to give a practical understanding of textile procedure.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
TE	211	Chemistry and Physics of Textile Fibers	(3-1)3
TE	263	Textile Systems I	(3-1)3
		Total hours	(16-4)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
ME	208	Introduction to Kinematics	(3-0)3
TE	264	Textile Systems II	(3-3)4
		General Elective	(3-0)3
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	215	Analytic Mechanics I	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
TE	331	Textile Systems III	(3-1)3
		General Elective	(3-0)3
		Total hours	(17-4)18

Second Semester

EC	202	Economics II	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	216	Analytic Mechanics II	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
TE	332	Textile Systems IV	(3-3)4
		General Elective	(3-0)3
		Total hours	(17-3)18

SENIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	395	Materials Science	(3-0)3
ME	453	Senior Project I	(0-3)1
ME	488	Environmental Conditioning	(3-0)3
TE	433	Technology of Knitting	(2-3)3
TE	459	Textile Systems V	(3-0)3
		Technical Elective*	3
		Total credit hours	19

*ROTC students may substitute AS 401

Second Semester

ME	454	Senior Project II	(0-6)2
TE	460	Textile Systems VI	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
		Technical Elective	3
		General or Technical Elective*	3
		Total credit hours	16

*ROTC students may substitute AS 402

Technical Electives

EC	414	Engineering Economy	(3-0)3
ME	421	Machine Design	(2-3)3
TE	403	Modern Trends in Fabric Production	(2-2)3
TE	434	Advanced Knitting	(2-3)3
TE	482	Applications of Scientific Methods to Textile Processes	(3-0)3
TE	483	Engineering Design of Textile Structures I	(3-0)3
TE	484	Engineering Design of Textile Structures II	(3-0)3

Other MA, ME or TE subjects with the approval of the Department Head

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospace Studies	MA	Mathematics
BI	Biological Sciences	ME	Mechanical Engineering
BA	Business Administration	MY	Meteorology
CN	Chemical Engineering	NU	Nuclear Engineering
CH	Chemistry	PA	Paper
CE	Civil Engineering	PH	Physics
DP	Data Processing	PL	Plastics
EC	Economics	RS	Radiological Sciences
EE	Electrical Engineering	SS	Social Sciences
IM	Industrial Management	TE	Textile Engineering
LL	Languages and Literature		

SUBJECT NUMBERS

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are normally for graduate students but may be taken by undergraduates in certain cases with special permission.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

PREREQUISITES

Prerequisites and restrictions are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

CLASS AND CREDIT HOURS

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AEROSPACE STUDIES

AS 101-102 U.S. Military Forces in the Contemporary World I and II (1-1) (1-1)2

An introductory course exploring the background, mission, and functions of U.S. Military Forces. Particular emphasis is placed upon the mission and organization of the US Air Force and the responsibilities of an Air Force officer. The course continues with an in-depth study of US strategic offenses and defensive forces and ends with an examination of the specific functions of US General Purpose and Aerospace Support Forces. This study will serve as a foundation for an introduction to the defense policy instruction offered in AS 201-202.

AS 201-202 U.S. Military Forces in the Contemporary World III and IV (1-1) (1-1)2

A brief study of defense policies as related to the strategies of the United States, the Soviet Union and China. The course continues with the study of defense organization, the role of the military in United States national policies and concludes with an examination of the factors involved in defense decision making.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the changing nature of military conflict; airpower in the United States; mission and organization of the U.S. Air Force; Air Force concepts, doctrine and employment of aerospace power, including US space programs, vehicles, systems, and problems in space exploration. These areas are studied through the media of briefings, discussions, debates and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership and introductory management principles. Classroom and organizational situations allow application of leadership and management skills, stress professional and personal responsibility and improve communicative skills through classroom discussions and student presentations.

BIOLOGICAL SCIENCES

BI 201 Principles of Biology (3-3)4
[CH 102, CH 104]

Part one of a basic course which includes an introduction to cell structure, cellular metabolism, molecular genetics, protein synthesis, bacteria and viruses, and systems of the human body.

BI 202 Principles of Biology (3-3)4
[BI 201]

Part two of a basic course dealing with the structure, function, and diversity of living organisms including a brief survey of the animal and plant kingdoms, photosynthesis, developmental biology, population genetics, ecology and evolution.

BI 301 Physiology (3-3)4
[BI 202]

Structural, chemical and physical aspects of important processes in mammals. Mechanisms operative at the molecular, cellular, and organismic levels related to (1) intake, transport, metabolism and excretion of gases and nutrients, (2) immune protection, (3) muscle contraction and (4) integrative activity of the nervous and endocrine systems.

BI 306 Biochemistry (3-3)4
[CH 222 or 224, CH 232 or 336 concurrently]

Fundamental concepts in biochemistry including protein structure and biosynthesis; enzyme structures and mechanisms; nucleic acids and genetic development; metabolism; photosynthesis; cellular structure; functions and structure of carbohydrates, hormones, lipids, and hemins; chemical functions of organs.

BI 311 Microbiology (3-3)4
[BI 202]

A study of the morphology and the chemical and physical activities of representative bacteria, yeasts, molds, viruses and animal parasites as related to man. The laboratory covers basic qualitative and quantitative techniques of microbiology with an introduction to selected immunochemical methods.

BI 330 **Ecology** **(3-3)4**
[BI 202]

A course dealing with factors responsible for the relationships of living organisms to each other and to their natural environment. The nature and dynamics of the biotic community.

BI 332 **Botany** **(3-3)4**

An introduction to the plant kingdom dealing with the structure, function, and diversity of the different plant forms. The cytology, ecology, morphology, physiology, and taxonomy of plants will be considered.

BI 360 **Electron Microscopy** **(2-3)3**
[BI 202]

An introduction to the theory and operation of the electron microscope. Preparation of biological specimens for EM viewing and photography will be stressed. Applications in biology will be discussed.

BI 410 **Industrial Biology** **(3-0)3**

Fundamental aspects of physiology and microbiology followed by a consideration of the effects of chemical and microbial pollutants of air and water on biological systems. Pollution control, sanitation, food preservation as related to industrial management. Not open to biology majors.

BI 411-412 **Research in Biology** **(0-12) (0-12)8**

An individual, directed research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration, is required.

BI 420 **The Environmental Biology of Man** **(3-0)3**

This course will be centered on Man as a biological entity. His chemistry, cellular design, and physiology will be described, as well as his requirements for growth, repair, and reproduction. The extent to which he depends on other organisms and on chemicals in his environment to meet these requirements will be outlined. Specific examples will be cited to show direct or indirect imbalances in nature on Man's ability to meet his requirements. The importance of species interaction and their dependence on the physical environment will be emphasized. Not open to Biology Majors.

BI 451-452 Seminar in Biology (1½-0) (1½-0)2

Seminar discussion of selected topics of current research interest. Offered each semester by a different member in his special discipline. Student participation in the form of discussion and presentation of papers. For senior biology majors.

BI 456 Endocrinology (3-3)4
[BI 301]

Structure and physiology of the endocrine glands. Emphasis will be given to the synthesis, transport, and mechanism of hormone action with regard to regulation of intermediary metabolism and maintenance of an homeostatic microenvironment. Endocrine imbalances, resulting in disease will also be discussed.

BI 462 Radiation Biology (3-0)3
[BI 202, RS 441]

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and late effects in whole animals and the modification of radiation exposure by physical, chemical and biological factors.

BI 471 Genetics (3-0)3
[BI 202]

The laws of biological inheritance. The molecular basis of heredity is stressed. Replication of DNA, genetic codes and fine structures of chromosomes are considered.

BI 481 Immunology (3-3)4
[BI 311]

Lectures dealing with the theories of infection and immunity are correlated with a laboratory study of antigens, antibodies, and antiserums emphasizing immunochemical techniques.

BUSINESS ADMINISTRATION

BA 141-142 Accounting I and II (3-0) (3-0)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 143-144 Accounting Management I and II (3-0) (3-0)6
[I.M. Students Only]

These courses are designed to give the industrial management student an understanding of accounting concepts and techniques. Special emphasis on the role of cost accounting in the manufacturing process.

BA 191 Physical Science I (3-0)3

An introduction to the topics of physics and astronomy including: kinematics, dynamics, energy, heat, atoms and molecules, wave motion, electricity, magnetism and the solar system.

BA 192 Physical Science II (3-0)3

A survey of topics in modern physics, chemistry, and geology including: relativity, waves and particles, Bohr theory of the atom, periodic table, chemical bond, ions and solutions, chemical reactions, earth materials, and study of the atmosphere.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3

An analysis of the marketing of goods and services to final consumers and intermediate customers. The study of decision areas such as product planning, channels of distribution, promotion, and pricing is based upon a framework of consumer behavior, environmental forces, governmental constraints, and the existing structure of business institutions involved.

BA 324 Industrial Marketing (3-0)3
[BA 321]

Special problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing strategy. Cases will be used.

BA 325 Advertising (3-0)3
[BA 321]

Commencing on a foundation of the historical evolution of advertising and the economic and social role of promotion, this course takes an in-depth look at advertisers, advertising agencies, and media as well as advertising creation and evaluation.

BA 326 **Marketing Research** **(3-0)3**
[BA 321, EC 211]

The process of planning, executing, and evaluating marketing research which is the information-gathering function of marketing management. Students work on individual research projects in the course.

BA 331 **Business Finance** **(3-0)3**
[BA 142, EC 201-202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 **Money and Banking** **(3-0)3**
[EC 202]

The evolution of money and credit and their role in the economy. Monetary policies of the Federal Reserve System. The structure and operation of the commercial banking system and the creation of money. The role of other financial institutions and their effect on the economy.

BA 334 **Investment Management** **(3-0)3**
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 **Accounting V and VI** **(3-0) (3-0)6**
[BA 242]

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(3-0)3**
[BA 142]

Job lot, process, and standard cost systems, including joint and byproduct problems, and the managerial uses of cost data.

BA 346 **Managerial Accounting** **(3-0)3**
[BA 142]
(For Non-accounting Majors)

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 Business Law (3-0)3

Principles of commercial law encompassing a study of contracts, agency, employment, commercial paper and sales including the Uniform Commercial Code.

BA 363 Advanced Business Law (3-0)3
[BA 362]

The analysis of the legal principles underlying real and personal property, corporations, partnerships, trusts and estates.

BA 371 Production Principles (3-0)3

Principles of manufacturing organization and productive processes with emphasis placed upon the functions of production systems; operational planning and control; plant layout; materials handling; inventory and quality control.

BA 372 Production Management (3-0)3
[BA 371]

A case course in the application of the principles covered in BA 371. The cases are representative of a wide range of products and industries. Small, medium and large manufacturing enterprises are studied; consideration is given to intermittent, continuous, and job lot systems of production.

BA 402 International Business (3-0)3
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's computer installation.

BA 404 Computer Applications to Management (3-0)3
[BA 403]

An investigation of the applications of electronic computers in the management of business enterprises. Attention is given to problems of management under conditions of uncertainty, inventory and production control, queuing theory, linear and nonlinear programming.

BA 421 **Procurement** **(3-0)3**
[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 422 **Retailing** **(3-0)3**
[BA 321]

The organization, operation, and management of retailing institutions. Students will compare and evaluate various types of firms and current developments in the field.

BA 423 **Marketing Management** **(3-0)3**
[BA 321 and BA 326]

Analyzes the process wherein the marketing strategies and plans of a competitive firm are formulated, implemented, and adjusted over time. Utilizes cases to study the behavioral, quantitative, and environmental aspects of marketing decision-making.

BA 426 **Sales Management** **(3-0)3**
[BA 321]

Analyzes the management of the personal selling function in its broadest aspects. Topics include sales force organization, selection, training, compensation, supervision, and motivation. Cases are used to emphasize the application of general principles to actual management problems.

BA 431 **Financial Management** **(3-0)3**
[BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 441 **Auditing** **(3-0)3**
[BA 342]

Auditing will be studied through the use of current professional literature and selected case studies. Current auditing standards, practices and problems are examined in detail. The course will stress conceptual understanding rather than procedural problem solving.

BA 444 **Advanced Cost Accounting** **(3-0)3**
[BA 344]

Estimated cost systems, budgeting control with standard costs, and cost and profit analysis for decision-making purposes.

BA 445 Federal Income Taxes (3-0)3
[BA 142]

This course deals with the basic rules and regulations of the Internal Revenue Code as it effects the individual and the corporation. An understanding of the code is developed through lectures, assigned readings, research, and the solution of a wide variety of problems.

BA 448 Seminar in Accounting (3-0)3
(For Accounting Seniors Only)

Readings in accounting history and thought, economics as it relates to accounting, contemporary accounting problems, controversies in current accounting practice comprise the foundation of the seminar. Students select a contemporary accounting problem for research and preparation of a paper which is defended before members of the class.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 Industrial Relations (3-0)3
[BA 451]

Human interaction and group behavior in organized industrial settings, interpersonal intergroup conflict, motivation, and leadership.

BA 453 Organizational Behavior (3-0)3

Basic findings and concepts of the behavioral sciences will be related to the specific aspects of behavior in organizations. Individual and group behavior will be examined. The process of improving and achieving change in organizations using behavioral concepts will be explored.

BA 471 Analytical Methods in Management (3-0)3
[BA 321, BA 331, BA 371]

A survey of the quantitative techniques available to assist management in the decision making process. Applications in the functional areas of marketing, production, and finance will be explored.

BA 481 Insurance (3-0)3

Principals of risk and risk management. Emphasis on life, health, fire, and casualty insurance as methods of handling risks.

BA 492 Physical Distribution Management (3-0)3

Emphasis on the analytical needs involved in the management of the functions that comprise physical distribution: warehousing, inventory control, material handling, and industrial packaging. Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies in the United States.

BA 498 Business Policy (3-0)3
[Seniors in BA and IM only]

A study of the functions and responsibilities of general management and their interrelationships. Consideration will be given to the problems which affect the character and success of the total enterprise. Emphasis will be placed on corporate strategy, the setting of objectives, establishing policies, and structuring the enterprise.

BA 500 Research Seminar 3
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

CHEMICAL ENGINEERING

CN 203 Introduction to Chemical Engineering (3-3)4
[CH 102, MA 104]

Introduction to the field of chemical engineering. Units and dimensions used by engineers. Flow sheets. P-V-T relationships and the Gas Laws. Introduction to mass balances. Laboratory: calculating devices including Wang Calculator; library investigations; fluids flow laboratory; chemical engineering equipment and its use; technical reports.

CN 204 Chemical Engineering Calculations (3-0)3
[CN 203, MA 204 taken concurrently.]

Mass and Energy balances, including phase separation and elementary thermochemistry. Steady-state calculations and applications to chemical engineering processes. Introduction to unsteady-state concepts.

CN 206 Fluid Mechanics (2-0)2
[CN 203]

Introduction to fluid statics and application of fluid mechanics principles to the analysis of and design of fluid systems. Design of fluid meters and conduits. Friction factor, pressure drops in laminar and turbulent flow and introduction to boundary layer theory.

CN 209 Introduction to the Chemical Industry (3-0)3
[CH 102]

An overview of the Chemical Industry; its relationship with U. S. economy and other industries. Economic factors in industrial chemical production. Study of processes used to manufacture inorganic and organic chemicals, petrochemicals, petroleum products, products from coal, plastics and other chemical products. Intra- and inter-industry relationships. Costs and effect on international affairs.

CN 301 Mathematics for Chemical Engineers (3-0)3
[MA 204]

Study and application of advanced mathematical topics such as vectors, matrices, ordinary and partial differential equations, etc. in the solution of chemical engineering problems. Treatment and interpretation of engineering data.

CN 305 Transport Phenomena I (3-0)3
[CN 206, MA 204]

Macroscopic and differential momentum balances applied to the solution of viscous flow problems in laminar and turbulent flow. The same analysis is applied to energy balances and the solution of those equations in conduction heat transfer problems.

CN 306 Transport Phenomena II (3-0)3
[CN 301, CN 305]

Convective energy transport mechanisms and the application of those equations in the design of heat transfer equipment. Radiant energy transport. Introduction of mass transfer equations and the development of the molecular and convective diffusion in binary mixtures.

CN 310 Separation Processes (3-0)3
[CN 305, CN 306 taken concurrently]

Introduction to the design of multicomponent stage processes, such as distillation, absorption, extraction and humidification.

CN 311 Chemical Engineering Thermodynamics (3-0)3
[CN 305 taken concurrently]

Application of the First and Second Laws of Thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 312 Chemical Engineering Thermodynamics II (3-0)3
[CN 311]

A detailed rigorous treatment of topics not covered in CN 311. Additional material on general thermodynamic relations are developed for use in application of non-ideal gases and real substances. Interpretation of phase equilibrium data and applications are covered, as well as an introduction to statistical thermodynamics.

CN 315-316 Chemical Engineering Laboratory II and III (0-3) (0-3)2
[CN 305 and CN 306 taken concurrently]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports. Application of chemical engineering principles.

CN 319 Special Projects Credits to be arranged
[Approval of Instructor]

Research projects to be undertaken by the student with the supervision of a staff member. Usually will be an original problem. Reports required on project work.

CN 403 Reactor Design and Kinetics (3-0)3
[CN 306]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems. May be taken for graduate credit.

CN 408 Material Science (3-0)3
[Approval of Instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures. Corrosion and elementary electrochemistry. Structures of metals, non-metals, and polymeric materials. Structure of materials related to performance. May be taken for graduate credit.

CN 409 Economics and Process Analysis (3-0)3
[CN 304, MA 204]

Analysis of selected chemical processes from the overall view of chemical engineering technology and basic economics. Time value of money concept. Methods of depreciation. Factors of cost in a) plant design, b) plant operation. Term problems involving computer-based solutions.

CN 410 Plant Design (3-0)3
[CN 409]

Application of unit operations; economics and process analysis in the design of complete chemical plants. Flow sheets, specifications for equipment and an economic estimate of the total plant cost is required for successful completion of the course.

CN 414 Process Dynamics and Control (3-0)3
[CN 204, CN 301]

An introduction to chemical process control, description of processes and equipment by differential equations and the LaPlace transform. Representation of open and closed loop by block diagrams. Control loop stability is discussed together with

methods of representing dynamic behavior on Bode and Nyquist diagrams and related to experimental data. May be taken for graduate credit.

CN 416 Profession Orientation (1-0)1

A series of lectures and discussion groups primarily with seniors and graduate students to acquaint them with the mechanics of business, finance and taxes, unionism, organization of businesses and what is expected by industry and society of a professional engineer.

CN 419 Special Senior Projects Credits to be arranged
[Approval of Instructor]

Original research projects primarily in the chemical engineering field and supervised by a staff member of the Department. Reports required on work done.

CN 420 Analog Computer Techniques (3-0)3
[CN 301]

Application of analog computer concepts in the solution of chemical engineering and process dynamics problems. Use of the Department's EAI 380 analog computer is emphasized.

CN 503 Absorption and Extraction (3-0)3
[CN 301]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems. Use of computer in some problem solutions.

CN 506 Colloid Chemistry for Chemical Engineers (3-0)3
[Approval of Instructor]

Colloid chemistry principles applied to chemical engineering processes. Zeta potential and its applications; special problems involving surface chemistry and physics.

CN 507 Corrosion and Electrochemical Principles (2-0)2
[Approval of Instructor]

Electrochemical principles and physical chemistry relating to corrosion of metals. Materials of construction and design based on these principles. Prediction of metal behavior in process design.

CN 510 Water Resources Management (3-0)3
[Approval of Instructor]

A study of all actual and potential sources of potable and industrial water is made, giving particular attention to origin, chemical composition and possible sources of contamination. Methods of purification of water including reclamation of saline waters are studied in detail, particularly from a chemical engineering standpoint. Economic factors of purification and water distribution are also studied.

CN 511 Structure and Properties of Matter (3-0)3
[Approval of Instructor]

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering. Micro and macro structures related to end-use performance.

CN 517 Advanced Distillation (3-0)3
[CN 503]

Review of principles of mass separation. Multicomponent distillation. Design of columns and analysis of specific systems. Use of computers in solution of distillation problems.

CN 519 Advanced Chemical Engineering Thermodynamics (3-0)3
[CN 312]

A critical examination of classical thermodynamics from a chemical engineering viewpoint, emphasizing the fundamental laws. General thermodynamic relations are used to develop equations for pure, ideal gases and real substances. Selected topics in applications of thermodynamics to equilibrium systems, refrigeration and other equipment.

CN 521 Introduction to Environmental Engineering (3-0)3
[Approval of Instructor]

This course introduces the student to the problem of the magnitude and causes of environmental pollution, in all of its aspects. The problems of water and air pollution are given particular emphasis and the student is given special projects for investigation. The course covers primarily the assessment and evaluation of the magnitude of the problem but does not consider the known or possible solutions to the problem of environmental pollutions.

CN 522 Environmental Waste Management (3-0)3
[Approval of Instructor]

A detailed study is made of the various sources of wastes and pollution from municipal and industrial sources. The first part of the course emphasizes current methods of waste control and purification of waste waters with particular emphasis on the chemical engineering aspects of the technology. The last part of the course is involved with the present technology of handling of gaseous waste systems. Economic factors are emphasized and special projects are given for outside study.

CN 523 Air Resources Use and Control (3-0)3
[Approval of Instructor]

This course emphasizes the problems involved in air pollution and the technology developed for its control. Methods of analysis and the technologies of removing gaseous contaminants and particulate solids from waste gas streams are emphasized. The chemical engineering aspects of these techniques constitute a major portion of the course.

CN 527 Legal and Social Aspects of Environmental Pollution Reviews (3-0)3
[Approval of Instructor]

This course reviews the laws relating to air and water quality and to the social aspects of control of these parts of man's environment, environmental engineering and the control of environmental pollution. Such topics as the control of oil wastes in an ocean environment, specialized chemical discharges such as cyanides and other chemical wastes and thermal wastes from power plants are investigated. In all cases considerable emphasis is placed on the chemical engineering aspects of these pollution problems and their control. Special topics in the local area of real importance will also be considered.

CN 528 Intermediate Transport Phenomena (3-0)3
[Approval of Instructor]

An advanced study of the mechanics of momentum, heat and mass transfer. The equations of continuity, motion and energy are considered for several systems in steady and unsteady state processes. Transfer coefficients are defined as a microscopic and macroscopic level and the entire subject of unit operations are defined in terms of equations of change. Considerable emphasis is placed upon solutions to problems.

CN 538 Special Environmental Engineering Projects Credits to be arranged
[Approval of Instructor]

CHEMISTRY

CH 101 Chemical Principles (4-0)3

Treatment of scientific data and use of the slide rule are followed by consideration of the periodic table. The periodic properties of the elements are correlated with atomic structure. Theory of the chemical bond sufficient to undergird later topics precedes the study of inorganic nomenclature, stoichiometry, and the gas laws.

CH 102 Chemical Principles (4-0)3
[CH 101]

In this continuation of CH 101 are included a study of liquids, solids, organic chemistry, elementary thermodynamics, solutions, chemical kinetics, equilibrium, electrochemistry, acids and bases, and the reaction chemistry of the elements.

CH 103 Chemical Principles Laboratory (0-2)1

An experimental study of chemical principles and chemical transformations. Reactions of some important elements and compounds are examined and related to the periodic table. Considerable emphasis is placed on acquainting students with techniques, methods and instruments essential to quantitative chemical measurements. Topics include methods of chemical separation, reactions, organic synthesis, formula determination and adsorption spectroscopy.

CH 104 Chemical Principles Laboratory (0-2)1
[CH 103]

A continuation of the experimentation of CH 103 including determinations of molar volume, molecular weight, reaction rate, heat of reaction, redox potential and pH. Analytical chemistry is introduced with acid-base and oxidation reduction titrations. Careful observation and logical deduction techniques are encouraged.

CH 207 Inorganic Chemistry (3-3)4
[CH 102]

The chemical behavior, structures, methods of preparation, and nomenclature of the more important elements and their compounds. The laboratory illustrates basic principles used in the preparation and study of inorganic compounds.

CH 210 Analytical Chemistry I (3-4)4
[CH 102, CH 221, CH 232 concurrently]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometery, and spectroscopy.

CH 221 Organic Chemistry (3-4)4

Kernel-electronic formulation, nomenclature and mechanism of reaction of the following classes of chemical species: monatomic, diatomic, multiatomic molecules and ions, alkanes, alkenes, alkynes, other non-aromatic hydrocarbons, alkyl halides, organometallics, alkanols, alkyl esters of inorganic acids, dialkyl ethers, alkanoic acids and derivatives. The laboratory work consists of practice in planning and carrying out reactions to form products isolable by distillation.

CH 222 Organic Chemistry (3-4)4
[CH 221]

Formulation, nomenclature, mechanism of reaction, and overall equations for property reactions of the following classes of compounds: aldehydes; ketones; amines; organosulfurs; carbonic acid derivatives; multihydroxyaldehydes and derivatives including stereochemistry; carbohydrates; arenes; aryl halides; arenesulfonic acids; nitroarenes; arylamines; phenols; quinones; aromatic aldehydes, ketones, alcohols and carboxylic acids; multicyclic aromatic hydrocarbons and derivatives; heterocyclics and alkaloids. The laboratory work consists of instruction and practice in planning and successfully carrying out reactions to form solid products isolable by crystallization.

CH 223 Introductory Organic Chemistry I (3-3)4
[Primarily for students not majoring in chemistry]

Lectures in this course will include discussions of structures (with emphasis on molecular orbital theory and stereochemistry), classification by functionality, nomenclature, syntheses, and reactions and reaction mechanisms of organic compounds. The laboratory phases of the course work will be devoted to product separation and purification techniques, and methods of synthesis of industrially important organic compounds.

CH 224 Introductory Organic Chemistry II (3-3)4
[CH 223]

A continuation of the first semester subject (CH 223).

CH 232 Physical Chemistry (3-3)4
[MA 203]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 311 Analytical Chemistry II (3-4)4
[CH 210, CH 222, CH 333 concurrently]

The lecture consists of an introduction to simple and complex equilibria, kinetics, fundamentals of instrumentation and the chemical and instrumental bases of the tools of modern chemical analysis.

The laboratory furnishes instruction in fundamental analytical techniques from gravimetric and volumetric methods to use of modern instrumental techniques to separate, purify and determine the structure of unknown organic and inorganic compounds.

CH 321 Organic Chemistry Laboratory II (1-6)3
[CH 222]

A continuation of CH 222 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 333 Physical Chemistry (3-3)4
[CH 232]

Introduction to principles of statistical mechanics, kinetics, electrochemistry, and atomic and molecular structure.

CH 335 Principles of Physical Chemistry (3-3)4
[MA 203]

Similar to CH 232 and 333 but designed for students not majoring in Chemistry.

CH 336 Principles of Physical Chemistry (3-3)4
[CH 335]

A continuation of CH 335.

CH 342 Organic Qualitative Analysis (1-6)3
[CH 222]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403 Chemistry of High Polymers (3-4)4
[CH 222 or 224, CH 333 or 336]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereo-specific polymers, the chemistry of the more common polymers systems, and preparation of their corresponding monomers.

CH 404 Chemistry of High Polymers (3-4)4
[CH 403]

A continuation of CH 403.

CH 407 Undergraduate Thesis (0-9)3
[Permission of Department Head and Instructor]

Open only to Seniors majoring in chemistry. Research in analytical, organic, inorganic, physical, and polymer chemistry.

CH 408 Undergraduate Thesis (0-9)3

A continuation of CH 407. Both semesters must be taken and not more than six credits may be used in meeting degree requirements. Letter grades are given in both semesters. A written thesis is required following the conventional form of introduction, literature survey, results and conclusions. One copy of the thesis must be filed with the department office.

CH 409 History of Chemistry (1-0)1

A seminar course devoted to the discussion of the historical development of chemical principles. Each student is required to present ot the class a paper for discussion.

CH 413 Nuclear Magnetic Resonance and Electron Spin Resonance Spectroscopy (3-0)3
[CH 432]

An introduction to the essentials of nuclear and electron spin resonance is presented to illustrate the scope and application of the method. May be taken for graduate credit.

CH 423 Advanced Organic Chemistry (3-0)3
[CH 222]

Extension of introductory organic chemistry for chemistry

majors. Organic compounds and reactions are discussed in terms of reaction mechanisms, structure-reactivity and stereochemistry.

CH 424 Advanced Organic Chemistry (3-0)3
[CH 222]

Synthesis of organic molecules. Selected reagents and techniques are discussed with emphasis on the scope and limitations of these reactions. The reaction mechanisms are also discussed.

CH 431 Advanced Physical Chemistry I (3-0)3
[CH 333 or equivalent]

Extension of introductory physical chemistry. Open to seniors and first-year graduate students in chemistry and related fields. In the first semester, emphasis is placed on quantum chemistry of atoms and molecules.

CH 432 Advanced Physical Chemistry II (3-0)3
[CH 431 or equivalent]

Continuation of CH 431, with emphasis on classical and statistical thermodynamics of systems of chemical interest.

CH 434 Colloid and Surface Chemistry (3-0)3
[CH 232 or CH 335]

Theory of colloidal systems including physical chemistry of surfaces, electrokinetic pheomena and molecular kinetic and optical properties of colloids. Consideration is also given to thin layers and to foams and emulsions including the preparation of lyophobic colloidal systems, and the stability of lyophobic sols.

CH 442 Advanced Inorganic Chemistry I (3-0)3
[CH 333]

A theoretical treatment of the structure of the atom and inorganic compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics, theories of the chemical bond, crystal field theory, ligand field theory, and inorganic stereochemistry.

CH 445 Advanced Inorganic Chemistry II (3-0)3

A continuation of CH 442 with emphasis on the dynamics of inorganic systems. Reactions in aqueous solvents. Thermodynamics of coordination compounds. Kinetics of fast reactions with such topics as stopped-flow, temperature jump techniques.

CH 481 **Radiochemistry** **(2-3)3**
[CH 102, MA 204, PH 202]

An introduction to the fundamentals of radioactivity and radiochemistry. The laboratory work is directed to the detection and measurement of radioactivity. Designed primarily for majors in chemistry and allied fields.

CH 482 **Radiochemistry** **(2-3)3**
[CH 481]

A continuation of CH 481 with emphasis on the applications of chemical and nuclear principles and practices toward the preparation and separation of radionuclides. The laboratory experiments use such well-known techniques of separation as solvent extraction, ion-exchange, precipitation, coprecipition and electrochemical displacement.

CH 484 **Elements of Radiochemistry** **(2-3)3**

Chemical principles are reviewed and their applications to radiochemistry are discussed. Such topics as separation procedures and chemical identification of nuclides, radiation chemistry, and study of fission products are included in the course.

CH 502 **Color Science** **(2-3)3**

An analytical course of the concepts and methods of absorption and reflectance spectrophotometry, and color measurement. Encompasses both theoretical and applied methods for determining qualitative and quantitative composition of colored substances in transparent and opaque materials such as liquids, paper plastics, textiles, etc. Quantitative measurement of color, color difference, color matching and formulation by instrumental means based on the CIE and other trichromatic coordinate systems are studied. Computer usage and computer program developing problems are employed.

CH 503 **Chemistry of High Polymers** **(3-0)3**
[CH 222, CH 333]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 504 **Chemistry of High Polymers** **(3-0)3**
[CH 503]

A continuation of CH 503.

CH 505 Techniques of Polymer Chemistry (0-4)1

A laboratory subject to be taken concurrently with CH 503 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 506 Techniques of Polymer Chemistry (0-4)1

A continuation of CH 505.

CH 511 Biopolymers (3-0)3

Conformation and configuration of vinyl polymers and polypeptides. Helix-coil transitions in proteins and polypeptides. Biological specificity and macromolecular structure. Synthesis of stereoregular polypeptides. Structure and physical properties of nucleic acids. Relations of systhetic polymers to naturally occurring polymers.

CH 512 Bulk Properties of Polymers (2-0)2
[Permission of Instructor]

Structure and properties of bulk polymers in the glassy, rubbery, and crystalline states. Topics covered include chain statistics, rubber elasticity, the glass transition, segmental motion, and viscoelasticity.

CH 513 Spectroscopy (3-0)3
[CH 431 and 432]

A presentation of molecular spectra and molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results.

CH 514 Advanced Analytical Chemistry (3-0)3
[CH 431 or equivalent]

An emphasis is placed on the determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions.

CH 515 Chemical Literature (1-0)1

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Excercises in finding, assembling and using such data.

CH 516 Advanced Laboratory Technique (1-3)2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vac-

uum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 517 Glass Working (1-1)1

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 521 Physical Organic Chemistry (3-0)3

Modern and Classical Methodology in the study of organic reactions. Fast reactions, linear free energy relationships, tracer methods, instrumental techniques and other selected topics will be covered.

CH 522 Physical Organic Chemistry (3-0)3
[CH 424]

This is a course in theoretical organic chemistry. General topical coverage includes polarization effects, intermolecular forces including hydrogen bonding, reactivity indices, transition state theory and activation parameters, electronically excited organic molecules, isotope effects, stereoselection in elementary organic reactions, and selected special topics.

CH 523 Organic Reaction Mechanisms and Structures (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 Organic Synthesis (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate students only.

CH 531 Statistical Thermodynamics I (3-0)3
[CH 432 or equivalent]

Fundamentals of equilibrium statistical mechanics; classical and quantum statistics. Molecular theories of gases, crystals, and liquids, with emphasis on chemical aspects.

CH 532 Statistical Thermodynamics II (3-0)3
[CH 531]

Continuation of CH 531. Statistical thermodynamics of electrolyte and nonelectrolyte solutions; of polymer and polyelectrolyte systems; of chemical equilibria and reaction rate processes. Also, introduction to nonequilibrium statistical theories.

CH 533 **Quantum Chemistry I** **(3-0)3**
[CH 431 or equivalent]

Principles and methods of quantum mechanics with special attention to chemical applications, such as electronic structure of atoms and molecules, vibration and rotation of molecules, and interaction of radiation with matter.

CH 534 **Quantum Chemistry II** **(3-0)3**
[CH 533]

Continuation of CH 533. Further extension and additional applications.

CH 535 **Advanced Topics in Physical Chemistry** **(3-0)3**
[Permission of instructor]

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 536 **Advanced Topics in Physical Chemistry** **(3-0)3**
[Permission of instructor]

Same as CH 535, with different topics.

CH 537 **Chemical Thermodynamics** **(3-0)3**
[CH 333 or equivalent]

Basic laws of classical equilibrium thermodynamics as applied to macroscopic systems of chemical interest, including perfect and imperfect gases, ideal and nonideal solutions, electrolyte and nonelectrolyte solutions systems in chemical and phase equilibria, electrochemical cells, intersurface systems, etc. Also, introduction to thermodynamics of irreversible processes.

CH 540 **Chemical Kinetics** **(3-0)3**
[CH 443 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 543 **Modern Inorganic Chemistry I** **(3-0)3**
[CH 333 or equivalent]

Similar to CH 443 but designed specifically for graduate students. Emphasis is placed on the theoretical-physical concepts of importance to inorganic chemists.

CH 544 **Modern Inorganic Chemistry II** **(3-0)3**
[CH 543]

A continuation of CH 543 with emphasis on the mechanisms of inorganic reactions.

CH 549 **Physical Chemistry of Macromolecules I** **(2-0)2**
[CH 504 or equivalent]

Physical chemistry of high polymers, including macromolecular structure and conformation, chain statistics, polymerization kinetics, molecular weight distributions, and averages classical and statistical thermodynamics, hydrodynamic and optical properties of polymer and polyelectrolyte solutions.

CH 551 **Physical Chemistry of Macromolecules II** **(2-0)2**
[CH 549 or equivalent]

A treatment of various experimental methods involved in the determination of structural parameters of macromolecules, including among others viscometry, light scattering, thermal diffusion, ultracentrifugation and streaming birefringence.

CH 553 **Organic Chemistry of Macromolecules** **(3-0)3**

An advanced study in polymer science concerned with modern theoretical concepts and including synthesis, mechacules.

Offered in alternate years.

CH 554 **Stereochemistry of Macromolecules** **(3-0)3**
[CH 404, CH 424]

A treatment of modern methods applicable to the stereochemistry of macromolecules and including homogeneous and heterogeneous catalysis, methods of analysis, synthesis, mechanism, structural consequences generated from geometry, configuration or conformation and a statistical treatment of tacticity.

Offered in alternate years.

CH 561 **Advanced Organic Synthesis** **(3-0)3**
[CH 523 and 524, or equivalent]

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids,

antibiotics. Theoretical implications of organic reactions are also discussed.

Offered in alternate years.

CH 563 Chemistry of Natural Products (3-0)3
[CH 568, CH 311 or equivalent]

This course will cover the proof of structure of various types of natural products, approaches to the total synthesis of same and also the biosynthetic pathways.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy.

CIVIL ENGINEERING

CE 201 Surveying I (3-4)4
[MA 103, ME 104]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 202 Surveying II (3-4)4
[CE 201]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering.

CE 311 **Engineering Materials** **(2-3)3**
[CH 102, ME 220]

A treatment of the properties of engineering materials as such influence the design, construction and maintenance of Civil Engineering works. Included are such materials as ferrous and non-ferrous metals, timber, plastics, and cementitious materials. Also includes the description and identification of soils. Supplemented by laboratory testing of various engineering materials.

CE 312 **Structures I** **(3-0)3**
[ME 220]

An introduction to the principles of structural analysis with applications to typical Civil Engineering structures. Emphasis will be on the analyses of statically determinate planar structures.

CE 322 **Hydraulics** **(4-0)4**
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits. An introduction to the basic concepts of hydrodynamics and hydraulic similitude.

CE 342 **Transportation** **(3-3)4**
[CE 202]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic, materials of construction and the basic concepts of transportation economics, finance and administration.

CE 411 **Structures II** **(3-3)4**
[CE 312]

Analysis of statically indeterminate Civil Engineering structures employing classical and modern methods and treated as the initial steps in the total design concept.

CE 412 **Structures III** **(3-3)4**
[CE 411]

Design of structural elements and connections subjected to all types of stresses. Use and critical review of current design codes and application of these design principles to typical structures.

CE 413 **Concrete** **(3-3)4**
[CE 411 Concurrently]

Fundamental principles and concepts essential to the design and analysis of reinforced concrete structures. Research and its influence on design codes, study of elastic and inelastic behavior, and treatment of the rational foundations of design.

CE 421 **Hydrology** **(3-3)4**
[CE 322]

Theoretical principles underlying the use of the hydrologic phenomena of precipitation and water losses in the analysis and design of hydraulic structures. Methods of estimating stream flow under normal and flood conditions.

CE 431 **Soil Mechanics I** **(3-0)3**
[CH 102, CE 312]

Development of the fundamental principles of the science of soil mechanics as utilized in foundation engineering. Includes bearing capacity, percolation properties and settlement characteristics of soils as they affect the design of Civil Engineering structures.

CE 432 **Soil Mechanics II** **(3-3)4**
[CE 431]

Advanced theory of soil mechanics and its application to engineering analysis and design. Includes earth pressure theories, slope stability analysis, and the design of retaining structures and embankments. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties and behavior.

CE 961 **Advanced Surveying** **(2-1)2**
[45.32]
[For students in Engineering Technology only]

Application of higher surveying techniques to the providing of information and the solution of engineering problems. Topics covered include precise measurement of distances; precision measurement of angles; methods of determining elevations with high precision; consideration of photogrammetric techniques; and the basic principles of engineering astronomy.

CE 971 **Structures** **(2-1)2**
[25.52]
[For students in Engineering Technology only]

Review of elementary analysis of determinate structures with applications to more complex structures. Influence lines

and their applications. Calculation of deflections of beams, frames and trusses. The analysis of indeterminate beams, trusses and simple frames by currently applicable methods.

CE 981 Structural Analysis and Design (3-3)4
[CE 971, 45.52]
[For students in Engineering Technology only]

Analysis and design of beams and frames. Design of structural elements under typical stresses by use of current design codes.

CE 982 Hydrology (3-3)4
[25.46]
[For students in Engineering Technology only]

A practical treatment of the occurrence and distribution of rainfall, surface and groundwater flow. Use of hydrologic factors as components in the design of hydraulic structures.

CE 991 Concrete Analysis and Design (3-3)4
[25.53]
[For students in Engineering Technology only]

The review and extension of the application of current methods to the analysis and design of reinforced concrete structures. Use of design aids to facilitate the solution of selected problems.

CE 992 Soil Mechanics (3-3)4
[CE 971]
[For students in Engineering Technology only]

Introduction to soil mechanics including laboratory techniques, all with the emphasis on the application of principles. Encompasses the use of field and laboratory tests in the design of foundations and the treatment of highway embankments. Laboratory work includes soil classification, graduation tests, Atterberg limits, and the common soil strength and compressibility tests.

CE 994 Engineering Problems (2-1)2
[For students in Engineering Technology only]

Topical discussions covering the relationship of the engineer to such groups as the general public, governmental agencies, clients and contractors, legal entities, and other engineers. Case studies include engineering concerns in such areas as contracts and specifications, regulatory agencies including zoning boards, boards of appeals, and conservation agencies.

CE 995 — Engineering Laboratory — (0-3)1

[CE 971]

[For students in Engineering Technology only]

Introduction to the basic techniques in the testing of engineering materials to establish experimentally the basic stress and strain indices. Introduction to experimental stress analysis by laboratory methods.

NOTE: All numerical prerequisites will be found in the catalogue of the Division of Evening Studies.

DATA PROCESSING

DP 930 — Scientific Computer Programming — FORTRAN — (2-1)2

[MA 41]

[For students in Engineering Technology only]

A detailed study of the FORTRAN programming language for the Institute's computer with numerous mathematical examples and problems; introduction to advanced programming techniques and large data processing systems. Student will program several basic problems to completion.

ECONOMICS

EC 201 — Economics I — (3-0)3

The foundations and nature of economic principles. Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 202 — Economics II — (3-0)3

National income, money and banking, and monetary and fiscal policy.

EC 211-212 — Economic Statistics I and II — (3-0) (3-0)6

Measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 American Economic History (3-0)2

A study of the growth and development of the American economy from its European origins to the present.

EC 302 Labor Economics (3-0)3
[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 Microeconomic Theory (3-0)3
[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 Macroeconomic Theory (3-0)3
[EC 202]

An analysis of Keynesian and Post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 311 Mathematics for Economists (3-0)3
[MA 202, EC 303]

Mathematical background for the study of econometrics. Study of sets, functions, and limits; differentiation; integration; series; differential equations; vectors and matrices.

EC 401 Current Problems (3-0)3
[EC 303, BA 332, EC 402]

A seminar on selected problems which confront the contemporary American economy.

EC 402 Government and Business (3-0)3
[EC 202, BA 332]

An examination of the various governmental controls over business in the American economy. Emphasis on court interpretations of the antitrust laws and on the economic theory and political philosophy behind them.

EC 403 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 **Comparative Economic Systems** **(3-0)3**
[EC 303, BA 332]

Analysis of free-market and planned economics in theory and practice. Emphasis on the United States and the Soviet Union.

EC 407 **Econometrics** **(3-0)3**
[EC 212, 304]

The course will provide the student both theoretical and empirical knowledge of econometrics. Methods of handling data, quantative empirical estimates, and tests of economic theory.

EC 408 **History of Economic Thought** **(3-0)3**
[EC 303]

Analysis of the development of economic theory; emphasis on the rise of classical economic thought.

EC 409 **Growth Theory** **(3-0)3**
[EC 304, EC 311, BA 332]

Analysis of cyclical fluctations and long-term economic growth. Construction of economic growth models.

EC 410 **Economic Development of Less Developed Countries** **(3-0)3**
[EC 202]

The role of capital (private and social), technology, labor, governments, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 **Public Finance** **(3-0)3**
[BA 332]

Study of alternative methods of financing non-market enterprises. Special emphasis on the tax and expenditure policies of federal, state and local governments.

EC 412 **Managerial Economics** **(3-0)3**
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 414 — Engineering Economy — (3-0)3

[EC 202]

[Not for BA or IM students]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

EC 500 — Research Seminar — (3-0)3

[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.

ELECTRICAL ENGINEERING

EE 201 — Introductory Circuit Theory I — (4-0)4

[MA 104, PH 201 concurrently]

Terminal characteristics of ideal elements, active and passive. Ohm's Law and Kirchhoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis. Definition and consequences of linearity, superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits, Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics, energy relations, graphical differentiation and integration. First-order transients: initial conditions, natural response and natural frequencies. Network response to unit step function and unit impulse. Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane.

EE 202 — Introductory Circuit Theory II — (4-0)4

[EE 201]

Sinusoidal forcing function, complex numbers, phasors, sinusoidal steadystate. Average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton's theorems, superposition, reciprocity, maximum power and Tellegen's theorem in the frequency domain. Magnetic coupling, mutual inductance, ideal transformer. Impedance and admittance and hybrid parameters for a two-port network. Introduction to matrices and their use in circuit analysis.

EE 207 Basic Electrical Engineering Laboratory I (1-3)2
[EE 201 concurrently]

Experimental work designed to verify theory and to acquaint students with electrical measurement techniques: experiments on dc meters, bridges, and oscilloscopes. Remainder of experiments are correlated with course EE 201 and concern: resistive measurements, Kirchhoff's Laws, network theorems, conservation of power and maximum power transfer, inductance and capacitance, and first-order transients.

EE 208 Basic Electrical Engineering Laboratory II (1-3)2
[EE 207, EE 202 concurrently]

Experimental work designed to emphasize electrical measurement techniques of linear systems with time-varying signals. Waveform measurements with dc and ac meters as well as advanced use of the oscilloscope with experiments integrated with course EE 202. Experiments concern: second-order transients, impulse and step response, Kirchhoff's Laws for phasors, magnitude and phase measurements of impedance, network theorems, frequency response, resonance, inductance and transformers, and maximum power transfer.

EE 211 Fundamentals of Electricity (3-0)3
[MA 104, PH 201 concurrently]
[Not open to students majoring in Electrical Engineering]

An introduction to electric circuits. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state ac circuits, two-terminal networks, and two-terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]
[Not open to students majoring in Electrical Engineering]

A background subject in electronics presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211 concurrently]
ONot open to students majoring in Electrical Engineering]

An introductory laboratory course primarily devoted to the measurement of terminal characteristics of electrical machinery.

EE 311 Electronics Laboratory I (1-3)2
[EE 319 concurrently]

A laboratory course which explores the use of dual trace and differential amplifiers as oscilliscope plug-in units and other

electronic test equipment in the investigation of static and dynamic characteristics of the vacuum triode, the solid state diode, and the bipolar transistor. In addition experiments in solid-state physics are performed. The experiments in this course are closely coordinated with the subject material in course EE 319.

EE 312 Electronics Laboratory II (1-3)2
[EE 320 concurrently]

The laboratory experiments in this course are closely coordinated with the subject material in course EE 320. Experiments covering the following subject areas are performed: biasing configurations and stability for bipolar transistors, single stage bipolar and field effect transistor amplifiers, differential amplifiers, feedback amplifiers, and linear integrated circuits.

EE 319 Electronics I (4-0)4
[PH 201, EE 202]

Brief introduction to electronics using vacuum tube models and circuits, conduction mechanism, distribution, and flow of charge carriers in semiconductors. Junction diode physical electronics, diode circuits and models, theory of bipolar transistors leading to Ebers-Moll and hybrid-II models. Introduction to use of total and incremental bipolar transistor models.

EE 320 Electronics II (4-0)4
[PH 201, EE 202]

Theory of MOSFET and JFET leading to development of total and incremental models, determination of incremental parameters and biasing of bipolar, MOSFET, and JFET transistors. Low frequency and high frequency response calculations, multistage amplifiers, feedback amplifiers.

EE 321 Electrical Energy Conversion (3-0)3
[EE 211, MA 203]
[Not open to students majoring in Electrical Engineering]

The generation, control, utilization and conversion of electrical energy.

EE 327 Programming and Application of Digital Computers I (2-0)2
[EE 202]

Elementary computer organization and information flow concepts are developed. Number systems are reviewed with emphasis on binary addition and subtraction. The theme of problem interpretation and analysis is stressed through program

flow charting, coding, and documentation. FORGO and FORTRAN II-D programming languages are used to solve problems involving numerical integration, series solutions, list sorting, array manipulation, and elementary matrix operations. The interpretation and verification of computed results are stressed.

EE 328 Programming and Application of Digital Computers II (2-0)2

[EE 327]

The Boolean representation and the hardware implementation of the basic logical operations, half-adders and full-adders are developed. An introduction to programming techniques required in the development of large programs with emphasis on user-developed main programs that link disk-stored subprograms. Topics include definite and indefinite numerical integration, piecewise-linear function generation, first-order linear and nonlinear differential equations, simultaneous equations with real variables, determination of the magnitude and phase of rational functions, time-domain and frequency-domain plots.

EE 348 Basic Electrical Engineering Concepts (3-0)3

[MA 104]

[Not open to students majoring in Electrical Engineering]

An introduction to the basic principles of electricity; including the concept of voltage, current, resistance, inductance and capacitance; Ohm's and Kirchoff's Laws; Thevenin's and Norton's Theorems. Emphasis will frequently be placed on pointing out analogous problems in the chemical and mechanical engineering fields. Other areas of coverages will include transient and sinusoidal steady state analysis of RLC circuits, motor and generator concepts and an introduction to solid state devices including the semiconductor diode and transistor.

EE 351 Industrial Electronics (3-0)3

[MA 104]

[Not open to students majoring in Electrical Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum tube, gaseous-tube and semiconductor device characteristics and of circuits utilizing such devices for the purpose of rectification, amplification, and oscillation; and industrial photo-electric and time delay relays.

EE 353 Electrical Controls and Power Circuits (3-0)3
[MA 203]
[Not open to students majoring in Electrical Engineering]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and generators; manual and automatic electric controls including photoelectric relays, time delay relays and motor control.

EE 355 Introductory Electromechanics (3-0)3
[EE 202]

Introduction to magnetic circuits, energy in magnetic circuits, forces and torque in electromagnetic devices, power and communication transformers with equivalent circuits, frequency response, and losses. Electromechanical energy conversion principles and electromechanical transducers.

EE 360 Electromagnetic Theory I (3-0)3
[MA 204]

An intermediate course in electrostatics and magnetostatics using vector calculus. Topics include: the electric field, line and surface integrals, potential, the divergence theorem, Gauss's law, capacitance, conductors, dielectrics, Poisson's and Laplace's equations, the Biot-Savart law, Stokes's theorem, scalar and vector magnetic potentials, force and torque on conductors, magnetic circuits and inductance.

EE 362 Signal and System Analysis (3-0)3
[EE 202, MA 204]

Natural and forced response of linear systems; exponential excitation, impulse response, and system function. Fourier series analysis, impulse method of coefficient evaluation. Fourier transforms, complex Fourier transforms and Laplace transforms applied to linear systems analysis. Paley-Wiener criterion and causality. Distortionless ideal filters. Time-convolution in linear systems.

EE 403 Microwave Design Theory (3-0)3
[EE 461]

An introductory course in the analysis and design of passive microwave devices beginning with a review of time-varying electromagnetic field concepts and transmission lines. Impedance matching techniques, terminations, attenuators, phase changers, directional couplers, hybrids. Microwave devices employing Faraday rotation, electromagnetic resonators. Periodic structures. Microwave filter design.

EE 409 **Project Laboratory I** **(0-4)2**
[Permission of Instructor]

The purpose of this course is to provide an opportunity for qualified electrical engineering seniors to investigate specific areas of interest. Interested students apply for specific projects as advertised by staff members. At the discretion of the staff, students are assigned as individuals or team members to the projects. The projects themselves are research and development oriented and usually involve a substantial amount of laboratory work. A practical attitude and environment is maintained for the duration of the project. Design reviews, progress reports, and a final report is expected for each project.

EE 410 **Project Laboratory II** **(0-4)2**
[Permission of Instructor]

The purpose of this course is to provide an opportunity for a student to either continue his investigation undertaken in EE 409 or to initiate a new project which is not related to his EE 409 work.

EE 411 **Logic Design of Digital Systems I** **(3-0)3**
[EE 328]

An extension and elaboration of the number system, Boolean algebraic, and combinatorial logic concepts introduced in EE 328. An introduction to threshold and majority logic. Minimization techniques including Boolean algebraic manipulation, the Karnaugh map method, and the Quine-McCluskey tabular method. Simplification techniques are also applied to multiple output circuits and incompletely specified functions. Additional topics include basic digital system building blocks such as the adder and shift register, error detection and correction codes, and an introduction to sequential machines.

EE 412 **Logic Design of Digital Systems II** **(3-0)3**
[EE 411]

The general characteristics of finite synchronous and asynchronous sequential machines. State diagrams, state tables, implication tables and graphs are used to determine equivalent states and therefore equivalent minimal sequential machines. State assignment and complete machine logic design. Hazards in combinational and sequential networks. Introduction to neural networks, Turing machines, and automata.

EE 413 **Linear Feedback Systems** **(3-0)3**
[EE 362]

Concept of feedback: open loop and closed loop systems. Feedback in electrical, mechanical, biological, economic and

social systems. Mathematical models of systems and linear approximations. Transfer functions of linear systems, block diagrams and signal flow graphs. Sensitivity, control of transient response, disturbance signals. Time domain performance: steady state errors, performance indices. Stability related to s plane location of the roots of the characteristic equation. Routh-Hurwitz criterion. Graphical analysis techniques: root locus, frequency response as polar plots and Bode diagrams. Closed loop frequency response and Nichols chart.

EE 414 Feedback Control Systems (3-0)3
[EE 413]

Time domain analysis of feedback control systems, compensation, Truxal's emphasis procedure, complex control systems and ac carrier systems.

EE 416 Electronic Amplifier Circuits (3-0)3
[EE 320]

An integrated treatment of the analysis and design of electronic amplifiers. Topics such as noise, noise figure, intermodulation, intercept point, VSWR, and frequency response are covered. Emphasis is then placed on the choosing of electronic devices and circuit configurations based on amplifier and system design objectives.

EE 417 Absolute and Symbolic Programming (3-0)3
[EE 328]

An introduction to absolute and symbolic programming and coding fundamentals. Typical digital computer organization; breakdown of functional blocks including arithmetic unit, control unit, memory and input-output structure. Computer word formats; single and double precision, floating point and instruction words. Machine instructions and methods of execution. Symbolic coding. Address modification, index registers and looping. Subroutines, calling sequences and utility routines. Input-output programming, buffering, interrupt input-output. Macroinstructions. Table processing techniques. Programs will be run by students on the Electrical Engineering Department's HP 2116B computer.

EE 425 Wave Shaping and Generation I (3-0)3
[EE 320]

Principles and methods of wave shaping and wave generation using active and passive elements. Pulse transformers, delay lines, wideband amplifiers and steady-state switching characteristics of electronic devices. Clipping, comparator, clamping, and switching circuits. Logic circuits.

EE 426 — Wave Shaping and Generation II — (3-0)3
[EE 425]

Bistable, monostable and astable multivibrators. Negative resistance devices and switching circuits. Voltage and current time base generators. Blocking-oscillator circuits, sampling gates, counting and timing, synchronization and frequency division.

EE 429 — Network Synthesis — (3-0)3
[EE 315, MA 315]

Review of linear system analysis methods: consideration of natural frequencies for impedance-by-inspection techniques. Tellegen's theorem: general reciprocity relation and driving-point impedance characteristics. Positive-real functions: definitions and tests. Hurwitz polynomials and Sturm tests. Properties of LCT, RCT, RLT, and RLCT one-ports with Cauer, Foster, and Brune network realizations. Partial-pole removals and introduction to transfer function realizations.

EE 435 — Special Topics in Electrical Engineering I — (3-0)3
[Permission of Instructor]

An analytic consideration of one or more special topics selected from recent developments in the field of electrical engineering.

EE 436 — Special Topics in Electrical Engineering II — (3-0)3
[EE 435]

Continuation of EE 435.

EE 439 — Introduction to Electrical Systems — (3-0)3
[EE 362 and EE 320]

An introduction to both power and communicative systems, including distributed constant transmission lines, power system operation, communication systems using amplitude, angular and pulse modulation, and a survey of radio propagation.

EE 440 — Electrical Communication Systems — (3-0)3
[EE 439]

A continuation of the study of communication systems including the statistical properties of signals and noise, data transmission, error detection and correction, signal to noise ratio and channel capacity of various systems.

EE 444 Electrical Power Systems (3-0)3
[EE 355]

Design and operation of present-day power networks considered both from the viewpoint of economy and reliability including the problems of power and frequency control, system stability and fault analysis.

EE 445 Analog Devices and Techniques (3-0)3
[EE 320]

A survey of analog devices and techniques. Primary emphasis is on general techniques although conventional analog computers are discussed extensively as examples of the application of the techniques. Operational amplifiers, multipliers, amplitude and time scaling.

EE 446 Digital Devices and Techniques (3-0)3
[EE 328]

A survey of digital services and techniques. Primary emphasis is on general techniques although conventional digital computers are discussed extensively as examples of the application of the techniques. Machine organization, number systems, Boolean algebra, arithmetic operations, memory devices, analog to digital conversion, and digital to analog conversion are discussed.

EE 454 Electromechanics (3-0)3
[EE 202, MA 204]

The principles of electromechanical energy conversion applied to rotating machinery, control systems, and devices such as microphones, loudspeakers, accelerometers, servomotors, and space vehicles. A first course for the student of electrical engineering who will use rather than design electromechanical devices.

EE 461 Electromagnetic Theory II (3-0)3
[EE 360]

Extension of EE 360 to time varying fields. Topics include: Faraday's law, displacement current, Maxwell's equations, plane waves, Poynting's theorem, skin depth, transmission line theory, Smith chart, simple antennas.

EE 463 Introductory Communication Theory (3-0)3
[EE 362]

Temporal waveform multiplication and frequency convolution applied to amplitude modulation. Introduction to phase and

frequency modulation. Bessel functions, bandwidth of FM signals. Sampling theorem and signal space. Multiplexing in frequency and time domains. Pulse modulation: amplitude, frequency, position and code (PCM). Signal comparison — correlation and energy spectral densities. Shot and thermal noise applied to linear systems — noise figure.

EE 465 Direct Energy Conversion (3-0)3
[EE 355 or EE 454]

Review of first and second law of thermodynamics; thermoelectric, photoelectric, and thermionic conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion. Nuclear fission, reactor theory, reactor control and operation, reactor shielding.

EE 471 Modern Energy Conversion Methods (3-0)3
[MA 204, PH 201]
[Not open to students majoring in Electrical Engineering]

Dc electromechanical energy conversion, synchronous converters, inductive energy conversion, transformers. Dynamic analysis using Lagrange's equations. Thermoelectric, thermionic and photoelectric energy conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion. This course is primarily intended to acquaint the nuclear engineer with the modern energy conversion methods available for use in conjunction with a nuclear reactor.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well qualified undergraduate students.

EE 503 Solid-State Physical Electronics I (3-0)3
[EE 360]

Introduction to the behavior of solid-state electronic devices from the viewpoint of modern physics: review of classical mechanics and Maxwell's equations. The Bohr atom, wave-particle duality, wave packets, Schroedinger's equation, band theory of solids, electrons and holes. Mechanical and acoustical properties of solids, semiconductor behavior.

EE 504 Solid-State Physical Electronics II (3-0)3
[EE 503]

Continuation of EE 503. Semiconductor devices: Schottky diodes, p-n junction devices, junction transistors, field-effect transistors, photo-diodes, varactors. Electro-optic devices, thermo-electric devices, electro-luminescent diodes and laser diodes. Magnetism and magnetic devices.

EE 505 Microwave Electronics I (3-0)3
[EE 461]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 506 Microwave Electronics II (3-0)3
[EE 505]

Continuation of EE 505

EE 507 Electromagnetics I (3-0)3
[EE 461]

Solution of Laplace's and Poisson's equations in rectangular, cylindrical and spherical coordinates. Green's function and conformal transformations. Also boundary value problems, radiation, transmission lines and wave guides will be treated.

EE 508 Electromagnetics II (3-0)3
[EE 507]

Continuation of EE 507

EE 509 Linear Systems Analysis (3-0)3
[EE 362]

Classical solution of linear systems described by differential equations. Duals, analogs, and electromechanical systems. System function, step and impulse response, and initial conditions. Time-domain convolution. Fourier analysis, series, and integral: impulse method for obtaining transforms. Laplace transforms: evaluation and properties. Complex variable theory: complex differentiation and Cauchy-Riemann equations. Complex integration: Cauchy's theorem and Cauchy's integral formulas. Taylor and Laurent series and the residue theorem. Inverse Laplace transforms. Introduction to Z-transforms.

EE 510 Systems Analysis-State Variable Techniques (3-0)3
[MA 533]

State variable formulation and solution of differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems with consideration of canonical forms for computer simulation.

EE 515 Nonlinear Control Systems (3-0)3
[EE 413]

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function,

the methods of Lyapunov and Popov and other nonlinear analysis techniques are treated.

EE 517 Optimal Control Systems (3-0)3
[EE 413]

A study of the analysis and design of optimal control systems. Both deterministic and random input signals are discussed. Introduction to adaptive control systems.

EE 519 Sampled-Data Control Systems (3-0)3
[EE 413]

The sampling process, reconstruction of sampled signals, the Z transform. Block diagram and signal flow graph representation of sampled-data systems and the time response of such systems.

EE 521 Automata Studies (3-0)3
[EE 412]

Mathematical foundation of automata, including probabilistic logics, neuron analogs, Turing machines, and learning theory.

EE 523 Digital Computer Softwave (3-0)3
[EE 563]

Examination of computer system softwave as an information processing function. Description of information structures. Formal languages, their syntax and semantics. Text processing programs and text editors. Assembly language and processing. Real-time system softwave. Time sharing and program sharing techniques in real-time systems.

EE 525 Simulation Techniques (3-0)3
[EE 328, EE 445]

A study of modern analog, digital and hybrid techniques for the simulation of continuous and discrete systems and processes. The student is expected to study a number of practical engineering systems through the use of simulation techniques on available analog, hybrid and digital computers.

EE 529 Network Synthesis I (3-0)3
[EE 362]

A review of natural frequencies and analysis techniques; complex variable topics such as conformal mapping, maximum modulus theorem, and Laurent series. Tellegen's theorem. Positive real (p.r.) functions developed from four different viewpoints, including reflection coefficients. Methods for testing p.r.

functions; Hurwitz test, Sturm test, and residue tests. Quadratic forms and the testing for p.r. matrices. Properties of the driving-point and transfer immittances of LCT, RCT, and RLT networks, Cauer and Foster network realizations, partial pole removals. Cauer transformations. RLCT Brune realizations.

EE 530 Network Synthesis II (3-0)3
[EE 529]

RLCT driving-point synthesis methods of Darlington, Bott-Duffin, Miyata and Fialkow-Gerst. Transfer synthesis methods of Darlington, constant-resistance lattice, RC ladder. Approximation problems using Butterworth functions, dissipation and predistortion techniques. An introduction to active network synthesis.

EE 537 Introduction to Bio-Medical Engineering (3-0)3
[EE 320]

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed.

EE 539 Biological Systems (3-0)3
[EE 413, EE 445, EE 537]

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required.

EE 545 Coding Theory (3-0)3
[MA 533]

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail.

EE 547 Statistical Communication Theory (3-0)3
[MA 584]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 584]

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

EE 549 Introduction to Lasers and Masers (3-0)3
[EE 360 or PH 353, EE 403]

A first course on Lasers and Masers not requiring quantum mechanics as a prerequisite. Classical electric and magnetic dipole models are developed to describe the quantum interaction between atoms or molecules and the radiation field. This course is designed to prepare the student to read the literature on the subject.

EE 551 Electro-Optics (3-0)3
[EE 362, EE 461, EE 549]

Principles of optical propagation as described by the Fresnel-Kirchoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 552 Electro-Optics II (3-0)3
[EE 551]

Continuation of EE 551.

EE 561 Computer Organization and Design (3-0)3
[EE 411, EE 417]

A critical examination of the organization of present day digital computers from both the softwave and hardware points of view. Computer design with hardware-software trade-off. Comparison of instruction sets, their hardware implementation. Examination of the input-output structures of selected examples. Multi-processing and parallel processing. Detailed examination of a large system and of several mini-computers. Students are expected to simulate certain aspects of the example computers on available digital computers.

EE 563 System Programming (3-0)3
[EE 417]

The definition of system programming as programming in a multi-user environment. Programming with and for interrupts.

Reentrant programming, pure procedures. Communication between program modules. Nested calls, the push-down stack. Recursive program calls. Reentrant interrupt programming. Activation records and program sharing. Character and list handling routines. Input-output systems. Representative programs of the above topics will be programmed by the student in assembly language on the HP 2116B computer.

EE 571 Introduction to Radar Systems (3-0)3
[EE 439]

Introduction to both pulsed and C.W. radar systems. Detection of radar echos in noise. The radar equation and its use in estimating performance of a radar system. Estimation of range, direction and velocity of targets. Moving target indicators (MTI). Pulse compression and other advanced techniques. Discussion of elements of practical radar systems.

EE 975 Basic Electricity (3-3)4
[PH 942, 45.41]
[For Engineering Technology students only]

An introduction to electric circuits for students who have a background in basic principles of electricity and magnetism. Includes illustrative laboratory projects.

EE 978 Basic Electronics (3-0)3
[EE 975]
[For Engineering Technology students only]

A background subject in electronics presenting the properties and applications of vacuum tube and semiconductor devices. Intended for the student who will use rather than design electronic circuits.

INDUSTRIAL MANAGEMENT

IM 371 Operations Research (3-0)3

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 372 Production Problems (3-0)3
[BA 371]

A quantitatively oriented case course stressing the functional interrelationship of major manufacturing decisions facing

management. Emphasis will be placed on problems of operations management, including scheduling, inventory control and facilities design, and methods of implementation, applied theory of mathematical programming, simulation, statistical models and organizations design.

IM 483 Statistical Quality Control (3-0)3
[MA 383 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 500 Research Seminar V
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

LANGUAGES AND LITERATURE

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 207 Oral Business Communication (3-0)3

Techniques and ethics of oral presentation. Panels, discussions, and problems. Frequent use of language laboratory. Limited to fifteen students.

LL 209 Technical and Scientific Communication (3-0)3
[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature: to 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature: from 1865 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature: to 1865 (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature: from 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English literature from 1798.

LL 218 Afro-American Literature (3-0)3
[LL 111-112]

A study of poems, plays, short stories and novels by Negro-Americans from 1920 to the present, including Langston Hughes, Richard Wright, James Baldwin, Ralph Ellison, and others.

LL 219 The Film in Communication (3-0)3

The film as a medium for communication. Historical evolution of screen conventions. Emphasis on analysis and evaluation of film.

LL 222 Educational Broadcasting Philosophy (2-2)3
[Permission of Instructor]

OObjectives which may be set for various types of broadcast stations, and the formulation of plans to achieve these objectives. Station management and operations in each type of station with emphasis on student-run educational stations. The art of announcing and program development. Discussion of F.C.C. policy relative to educational broadcast stations.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 — Shakespeare — (3-0)3
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 235 — English Drama After Shakespeare — (3-0)3

A study of main trends in English dramatic literature from 1600 to the present: comedy of humors, comedy of manners, heroic tragedy, sentimental comedy, satire, problem play, theatre of the absurd. Readings will include representative work of Ben Jonson, Congreve, Dryden, Goldsmith, Sheridan, Shaw, Samuel Beckett, and others.

LL 238 — Science and Literature — (3-0)3

A study of primarily literary works with scientific subject matter. Major topics include (1) the scientist as hero, (2) aesthetic implications of scientific discoveries, (3) the controversy over the "two cultures." Wide range of readings from Lucretius to Brecht's **Galileo.** [Not a course in science fiction.]

LL 259-260 — Elementary German — (3-0) (3-0)6

Fundamentals of grammar and basic vocabulary. Audio-lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use. No credit for the first semester without the second.

LL 261-262 — Elementary Technical German — (3-0) (3-0)6

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. No credit for the first semester without the second.

LL 263-264 — Elementary French — (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary school training in French. No credit for the first semester without the second.

LL 265-266 — Elementary Russian — (3-0) (3-0)6

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary

level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use. No credit for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing skills in reading and writing. No credit for the first semester without the second.

LL 309 Woman in Modern Fiction (3-0)3

A study of the changing role of women in our society as viewed and recorded by the literary artist. The study will extend from Thomas Hardy and D.H. Lawrence to the present, and concentrate finally on the current Liberation movement.

LL 311 Creative Writing and Advanced Composition (3-0)3

A course designed to develop the student's natural ability in verbal expression. Original works of short fiction, poetry, and exposition will be presented and discussed at regular intervals throughout the term.

LL 313 Introduction to Continental Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 315 Myth and Symbol in Literature (3-0)3
[LL 111-112]

An examination of the use of myth and symbol in modern literature for its thematic and cultural-historical significance. Emphasis on the analysis literature selected from the works of Dostoevski, Gide, Mann, Conrad, D.H. Lawrence and others.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 318 The Evolution of the Existential Hero (3-0)3

The development of the alienated hero in fiction from Stendahl, and Camus with emphasis upon the works of the following authors: Stendhal; Melville; Dostoevski; Gide; Sartre; Camus; Hemingway and Beckett.

LL 319-320 The Image of Man in Western Thought (3-0) (3-0)6

The first semester is not a prerequisite to the second. Examination of the major ideas and cultural influences in Western Thought from the fall of Rome to the present as reflected in literature, the visual arts and music.

Semester I: The Latin Middle Ages to the French Revolution
Semester II: The Industrial and Scientific Revolution to the Emergence of the Absurd.

LL 333 Problems of Philosophy (3-0)3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 335 The Southern Renaissance in American Literature

An investigation of universal implications in "regional" literature: Faulkner, Flannery O'Connor, Robert Penn Warren, Eudora Welty, James Agee, William Styron, Ralph Ellison, Truman Capote, James Baldwin.

LL 341 Satire (3-0)3
[LL 111-112]

A study of a literary genre. Selected readings from Horace and Juvenal through Orwell and Burgess.

LL 342 Utopian Literature (3-0)0

A study of utopias from Plato through Bacon to Bellamy, Wells, and Clarke.

LL 344 Modern American Poetry (3-0)3

An inductive investigation into recent trends in American verse, using the work of Frost, Pound, Eliot, and Williams as instructive points of departure and culminating in student investigation of individual poets of special interest.

LL 345 Modern Irish Literature (3-0)3
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 Intermediate French (3-0) (3-0)6
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit. No credit for the first semester without the second.

LL 365-366 Intermediate Literary and Conversational Russian (3-0) (3-0)6
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records. No credit for the first semester without the second.

LL 367-368 Intermediate German (3-0) (3-0)6
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idiomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of significant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use. No credit for the first semester without the second.

LL 369-370 Intermediate Spanish (3-0) (3-0)6
[LL 268 or equivalent]

Intensified study of the language, with increased opportunity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits. No credit for the first semester without the second.

LL 435 English Literature of the Eighteenth Century (3-0)3
[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectual background.

LL 436 English Romantic Poets (3-0)3
[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

LL 443 Science Fiction (3-0)0

A study of major works in science fiction and fantasy from Wells and Tolkien through Heinlein and Delaney. Emphasis is literary and historical.

LL 444 Popular Culture (3-0)3

A study of the Hero in American popular culture. Selected heroes include the Cowboy, the Tough Guy, the Secret Agent, the Politician, the Black, and the Musician. Movies, records, magazines, TV, and popular literature will be used.

LL 467 Seminar in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3
[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulker, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant

plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 Nineteenth-Century British Novel (3-0)3
[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 481 Classical Literature (3-0)3

An examination of the contributions of the Greeks to our literary culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

LL 482 The Short Story (3-0)3

A critical survey of the growth and development of the short story. Consideration of the works of key writers in this genre.

LL 495-496 Reading and Research (3-0) (3-0)6
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideration for admission limited to Juniors and Seniors with "B" average.

LL 961 British Literature (3-0)3
[For students in Engineering Technology only]

An introduction to British Literature from the Anglo-Saxon Period to the Contemporary Period, with emphasis on major authors and key periods.

LL 962 American Literature (3-0)3
[For students in Engineering Technology only]

An introduction to the literature of the United States from the Colonial Period to the Contemporary Period, with emphasis on major authors and historical background.

MATHEMATICS

MA 101 Mathematical Analysis I (3-0)3

Review of algebra, factoring, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, mathematical induction, progressions, logarithms, mathematics of investment, permutations and combinations.

MA 102 Mathematical Analysis II (3-0)3

Analytic geometry; circle, parabola, ellipse, hyperbola. Calculus; differentiation, optimization of functions, integration, and applications of calculus to business operations.

MA 103 Calculus I (3-0)3

Functions and graphs, equations of straight lines, the conics, the differentiation of algebraic functions together with applications involving tangent lines and velocity and acceleration, scalar product of two-dimensional vectors, the indefinite integral and area under a curve.

MA 104 Calculus II (3-0)3
[MA 103]

Applications of differentiation involving related rates, differentials, maxima and minima; methods of integration including parts, trigonometric substitution and partial fractions; the differentiation and integration of exponential, logarithmic and trigonometric functions; hyperbolic functions, and parametric equations.

MA 201 Mathematical Analysis III (3-0)3
[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 Mathematical Analysis IV (3-0)3
[MA 201]

Linear programming with graphs and ordinary algebra, vector algebra and matrix algebra used in linear programming, simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and applications of calculus in business operations.

MA 203 — Calculus III — (3-0)3
[MA 104]

Applications of integration including volumes, length of arc, curvature, work and center of gravity; determinants, scalar and vector products of three-dimensional vectors, partial differentiation, the solution of differential equations including linear, exact, homogeneous and nonhomogeneous; applications of differential equations.

MA 204 — Calculus IV — (3-0)3
[MA 203]

Applications of multiple integration including volumes, areas, center of gravity, and moment of inertia; polar coordinates, series including MacLaurin's and Taylor's; applications of series including series solutions of differential equations.

MA 221 — Linear Algebra — (3-0)3
[MA 104]

Mathematical induction, the properties of sets, mappings and mathematical logic; vectors in R_n, vector spaces, matrices, linear mappings, the effect of a change of basis, the matrix associated with a linear map; applications to geometry.

MA 222 — Linear Algebra — (3-0)3
[MA 221]

Scalar products and orthogonality, matrices and bilinear maps, polynomials and matrices, triangulation of matrices and linear maps, the Spectral Theorem, matrix analysis, applications to differential equations.

MA 301 — Advanced Calculus for Applications — (3-0)3
[MA 204]

Series solutions of ordinary differential equations, special functions, Laplace transformation, vector calculus, and matrices.

MA 302 — Advanced Calculus for Applications — (3-0)3
[MA 301]

Fourier series and integrals, boundary value problems and orthogonal functions, partial differential equations, partial differential equations, partial differential equations in engineering problems, and complex analysis.

MA 305 — Introduction to Real Analysis — (3-0)3
[MA 204]

Sets and functions, equivalence and countability, sets and sequences of real numbers, limits and metric spaces.

MA 306 Introduction to Real Analysis (3-0)3
[MA 305]

Continuous functions in metric spaces, connectedness, completeness, compactness, the Riemann integral, derivative, the Lebesgue integral.

MA 315 Complex Variables for Engineers (3-0)3
[MA 204]
[For Electrical Engineering Majors]

Functions of complex variables with special emphasis on Electrical Engineering applications, analytic functions, derivatives, Cauchy-Riemann conditions, Laplace's equation and conjugate functions. Line integrals, Cauchy's integral theorem, integral formula and residue theorem. Classification of singularities, properties, and applications of Taylor and Laurent series. Calculus of residues, maximum modulus theorem and Bronwich integral. Conformal mapping including Schwarz-Christoffel and Bilinear fractional transformations.

MA 321 Modern Algebra (3-0)3
[MA 222]

Elementary group theory, groups, cosets, normal subgroups, quotient groups, isomorphisms, homomorphisms, series of groups, the Sylow Theorems, free groups and homology groups.

MA 334 Projective Geometry (3-0)3
[MA 222]

Foundations of geometry, homogeneous coordinates, projective spaces, conics, linear transformations and surfaces.

MA 343 Advanced Differential Equations (3-0)3
[MA 204]

Formulation, solution and applications of linear and nonlinear ordinary differential equations, existence and uniqueness theorems, transform and numerical methods.

MA 344 Advanced Differential Equations (3-0)3
[MA 343]

Difference equations, boundary value problems, partial differential equations of mathematical physics.

MA 361 Digital Computer Programming (2-0)2
[MA 104]
[Offered both semesters]

An introduction to digital computer programming with concentration on the preparation of programs in the Fortran pro-

gramming language. The Institute's computer will be used for processing of practice problems.

MA 362 Numerical Analysis (3-0)3
[MA 203 and 361]

Numerical methods for solving engineering problems including: finite and divided differences, collocation polynomials, interpolation, numerical intergration and differentiation, solution of differential equations, systems of linear and nonlinear equations, root-finding techniques, and curve fitting. Computer applications are stressed throughout.

MA 381 Operations Research I (3-0)3
[MA 104 or MA 202]

The use of decision models in industrial systems. Quantitative approach to the industrial alternative. Fundamentals of probability and statistics, PERT techniques, methods of optimization using calculus, inventory control models and queuing models.

MA 382 Operations Research II (3-0)3
[MA 381]

A continuation of MA 381. Topics include: linear programming, transportation models, nonlinear programming, dynamic programming, games and strategies, Markov analysis, and simulation techniques.

MA 383 Statistical Methods (3-0)3
[MA 104]
[Offered both semesters]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 407 Introduction to Probability Theory (3-0)3
[MA 204]

Study of sample spaces, combinatorial analysis, probability distributions, random variables, central limit theorem.

MA 408 Introduction to Mathematical Statistics (3-0)3
[MA 407]

Treatment of data, measurements of dispersion, sampling, estimation, tests of hypotheses, regression theory and study of correlation.

MA 411 **Complex Variables I** **(3-0)3**
[MA 204]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals; Cauchy integral formula; power series and residues and poles.

MA 412 **Complex Variables II** **(3-0)3**
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 422 **Topics in Algebra** **(3-0)3**
[MA 321]

Elementary ring and field theory, quotient rings and ideals, homomorphisms or rings, rings of polynomials, algebraic extensions, automorphisms of fields, separal extensions. Galois Theory, introduction to categories and functions.

MA 431 **Topology I** **(3-0)3**
[MA 305]

Cardinality, partially ordered sets and Zorn's lemma, topology of the line and plane, topological spaces, continuity and topological equivalence.

MA 432 **Topology II** **(3-0)3**
[MA 431]

Metric and normed spaces, compactness, connectedness, product spaces, function spaces, fundamental group.

MA 434 **Matrix Algebra** **(3-0)3**
[MA 204]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 452 **Applications of Numerical Analysis** **(3-0)3**
[MA 204 and MA 361 or Equiv.]

Iterative solutions of transcendental equations. Rapidity of convergence and error estimates. Numerical differentiation and integration. Extrapolation and Romberg quadrature, interpolation, numerical solution of ordinary differential equations. Predictor-corrector formulas. Partial differential equations. Applications, computer solutions.

MA 475 Mathematical Logic (3-0)3
[Senior Standing]

Propositional and statement logic. A rigorous development of the science of deductive logic with an emphasis on the nature of the logical structure underlying mathematical systems.

MA 497 Foundations of Mathematics (3-0)3
[Senior Standing]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 498 Mathematics Seminar (3-0)3
[Senior Standing]

Student reading, writing and criticism, topics from current literature, and review of some important elements of the undergraduate work.

MA 501 Advanced Real Analysis I (3-0)3

Introduction to the real and complex number systems, elements of set theory including the Bolano-Weierstrass and Heine-Borel theorems, numerical sequences and series, continuity.

MA 502 Advanced Real Analysis II (3-0)3

Differentiation, Riemann integration, sequences and series of functions, and functions of several variables.

MA 511 Complex Analysis I (3-0)3

Topology of the complex number, analytic functions, Cauchy integral theorem, Cauchy integral formula, power series, residue calculus and applications, entire functions.

MA 512 Complex Analysis II (3-0)3

Picard's theorems, Riemann mapping theorems, Weierstrass P-function, prime number theorem, analytic continuation, Riemannian manifolds, Weierstrass monodromy theorem, Weierstrass factor theorem, Mittag-Leffler theorem.

MA 533 Matrix Theory (3-0)3
[MA 204]

Algebra of vectors, matrices, linear transformations and vectors, matrices and determinants, linear transformations and vector spaces, characteristic values and diagonal forms, calculus of matrices, matric polynomials, matric differential equations and applications.

MA 542 Fourier Series and Boundary Value Problems (3-0)3
[MA 204]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics and engineering, and boundary value problems.

MA 547 Integral Equations (3-0)3

Exact, iterative, and numerical techniques for the solution of linear Volterna and Fredholm integral equations; theorems for general operators; symmetric kernels, orthognal system of functions and the Hilbert-Schmidt theorem; relation of integral equations to differential equations; application of the Rayleigh-Ritz, Galerkin, and variation-iteration techniques to the solutions of eigenvalue-eigenfunction problems occuring in Mathematical Physics and Engineering.

MA 551 Calculus of Variations
[MA 204]

The first variational problem; necessary conditions; Euler's equation. Generalization to several dependent and independent variables. Constraints and Lagrange multipliers. Applications to dynamics and elasticity. Hamilton equations, Sturm-Liouville problems, direct methods; Rayleigh-Ritz method.

MA 575 Operational Mathematics (3-0)3
[MA 204]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Applications in the analysis of vibrations, deflections, and electric circuits, problems in partial differential equations, and Fourier transforms.

MA 584 Analysis of Random Processes (3-0)3
[Permission of Instructor]

Axiomatic definition of Probability. Combined Experiments, Bernoulii Trials, Asymptotic Theorems, Bayes Theorem. The concepts of both discrete and continuous random variables, and functions of one or more random variables. The use of continuous probability density functions to describe both discrete and continuous phenomena. Expected value, moments, characteristic functions, mean square estimation. Sequences of continuous random variables, convergence concepts, law of large numbers, Central Limit Theorem.

MECHANICAL ENGINEERING

ME 104 Design Graphics (1-0)1

The design process, sketching; pictorial methods; conventional representation; graphs, diagrams; presentation of ideas.

ME 205 Introduction to Engineering Design (2-3)3
[ME 104]

The process of mechanical design, with emphasis on graphical communication and layout. Lectures on design, drawing, dimensioning, fasteners, gears, cams, bearings and manufacturing techniques. Laboratory experiences in sketching, layout and design drawing. Demonstrations of machine tool operations including numerical control. Students must complete a comprehensive design project.

ME 206 Mechanical Engineering Laboratory I (3-0)1
[ME 220, ME 242 Concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in mechanics of materials and thermodynamics.

ME 208 Introduction to Kinematics (3-0)3

A study of the basic principles of kinematics. Topics involved are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms. Available equipment serves as the basis of problems and assignments.

ME 211 Mechanics I (3-0)3
[MA 104, PH 101]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situations. The concept of stress and strain at a point. The stress-strain-temperature relations.

ME 212 Mechanics and Properties of Matter (4-0)4
[MA 204 concurrently]
[Primarily for EE students]

This course covers selected topics in Mechanics which are of fundamental importance to students majoring in Electrical Engineering. These include equilibrium of rigid and deformable solids, elastic moduli, kinematics, dynamics. Newton's laws,

energy and momentum methods. Emphasis is given to colliding particles, central force systems, vibrating systems, and electrical analogues. Vector methods are stressed.

ME 215 Analytic Mechanics I (3-0)3
[MA 104, PH 101]
[Primarily for CN, PL, and TE students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Analytic Mechanics II (3-0)3
[ME 215]
[Primarily for CN, PL, and TE students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 Mechanics of Materials I (3-0)3
[MA 203, ME 211]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 242 Thermodynamics (3-0)3
[MA 203, PH 102]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability. Energy Conversion cycles.

ME 271 Machine Tool Laboratory (1-3)2
[Primarily for IM and PL students]

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 304 Materials Laboratory (0-3)1
[ME 220, ME 309]

Use of various testing equipment to establish material parameters used in structural analysis.

ME 307 Mechanical Engineering Laboratory II (0-3)1
[ME 309, ME 382, ME 395, all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, fluid mechanics and materials science.

ME 308 Mechanical Engineering Laboratory III (0-3)1
[ME 343, ME 354, both concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics systems and heat transfer.

ME 309 Dynamics I (3-0)3
[MA 204, PH 102]

Kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. D'Alembert's principle. Impulse and momentum.

ME 315 Applied Mechanics (3-0)3
[MA 104, PH 101]
[Primarily for IM students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 Machine Design I (2-3)3
[ME 220, ME 309]

The principles of mechanics, and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 343 Heat Transfer (3-0)3
[ME 242, ME 382]

Mathematical theory and applications of steady and transient heat conduction in solids. Heat transfer in convection and application to heat exchangers. Hydrodynamic and thermal boundary layer theory. Development of thermal radiation theory and its application to heat exchange with and without absorbing gases. Combined heat transfer by conduction, and radiation.

ME 344 **Heat and Power** **(3-0)3**
[MA 104, PH 102]
[Primarily for IM students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 347 **Elements of Thermodynamics and Heat Transfer** **(3-0)3**
[MA 203, PH 102]
[Primarily for CE, EE, and TE students]

A study of the first and second law of thermodynamics with application to systems and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases.

ME 354 **Dynamic Systems** **(3-0)3**
[MA 301, ME 309]

Unified approach to the modeling of simple mechanical, electrical, thermal and fluid systems. Transient and steady-state response of first and second order systems via classical and Laplace transform techniques. Supporting laboratory exercises emphasize real system behavior and associated physical measurement problems; error analysis.

ME 372 **Strength of Materials** **(3-0)3**
[ME 315]
[Primarily for IM students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 373 **Plastics Mold and Die Design** **(2-2)3**
[Primarily for PL students]

The fundamentals and basic principles of mold and die design for injection, compression, transfer, thermoforming and extrusion processes. Design considerations will include metal selection, runner and gate construction for the various polymeric materials. Laboratory will consist of actual design of a mold or die, with emphasis on relative drafting.

ME 376 **Plastics Mold Design and Construction** **(0-3)1**
[ME 271, ME 373]
[Primarily for PL students]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The

design and construction of simple molds is carried out by actual laboratory work for use on the machines in the Department of Plastics Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 Fluid Mechanics I (3-0)3
[MA 301 concurrently]

Development of basic fluid mechanical relations; continuity, momentum, and energy equations. Lagrangian v. Eulerian approaches. Applications to inviscid and viscous, incompressible flows. Similarity and dimensional analysis. Boundary layer concepts and mathematical description. Fundamentals of turbulence. Introduction to low speed aerodynamics. Development of angular momentum principles and their application to turbomachinery.

ME 384 Fluid Mechanics (3-0)3
[MA 204]
[Primarily for TE students]

Fluid statics; pressure and fluid forces, buoyant forces. Flow of "ideal" fluids. Equations of continuity and momentum. Dimensional analysis; π-theorem. Flow of "real" fluids; viscous effects, boundary layer, drag, pipe networks, open channel flow. Fluid measurements, and turbomachinery.

ME 395 Materials Science (3-0)3
[CH 102, PH 102]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 407 Mechanical Engineering Laboratory IV (0-3)1
[ME 413, ME 417, ME 497, all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, gas dynamics and automatic controls.

ME 413 Gas Dynamics (3-0)3
[MA 302, ME 242, ME 382]

Thermodynamics of gas mixtures and chemical equilibrium. Extension of basic equations of motion and energy to inviscid, compressible flows. Acoustic equations. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Crocco's theorem. Prandtl-Meyer expansion. Method of characteristics. Linearized flow theory.

ME 417 Dynamics II (3-0)3
[MA 302, ME 309]

Work-energy relation. Conservative force fields. Impulse and Momentum. Conservation of energy. Generalized coordinates and Lagrange's Equations. Vibrations of single and multiple degree of freedom systems.

ME 419 Nondestructive Evaluation Techniques (3-0)3
[Senior Standing]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical and metallurgical properties. May be taken for Graduate Credit.

ME 421 Machine Design (2-3)3
[ME 216]
[Primarily for TE students]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered.

ME 422 Machine Design II (2-3)3
[ME 320]

A continuation of ME 320. Laboratory problems emphasize aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria. May be taken for Graduate Credit.

ME 428 Kinematic Mechanism Synthesis (3-0)3
[ME 309]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis. May be taken for Graduate Credit.

ME 453 Senior Project I (0-3)1
[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members. The first term is devoted to problem definition, solution synthesis and design analysis.

ME 454 Senior Projects II (0-6)2
[Senior Standing]

A continuation of ME 453. The second term is devoted to trade off and optimization, construction, testing, evaluation and reporting.

ME 462 Engineering Analysis (3-0)3
[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Problem examples include both discrete and continuous systems encountered in the fields of solid mechanics, fluid mechanics, heat transfer, and electrical networks. May be taken for Graduate Credit.

ME 468 Fluid Machinery (3-0)3
[ME 413]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-dimensional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation. May be taken for Graduate Credit.

ME 472 Experimental Stress Analysis (2-3)3
[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distributions by experimental methods. Photoelasticity, birefringent coatings, brittle coating, analogies,

strain gage applications, rosette analysis. May be taken for Graduate Credit.

ME 473 Mechanics of Materials II (3-0)3
[MA 302, ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center; unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections. May be taken for Graduate Credit.

ME 474 Thermodynamic Applications (3-0)3

Application of the laws of thermodynamics to power cycles and refrigeration cycles. Multiphase mixtures. Thermodynamics of reacting systems, equilibrium criteria, heats of reaction, completeness of reaction, dissociation. May be taken for Graduate Credit.

ME 475 Physical Metallurgy (3-0)3
[ME 395]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phenomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture. May be taken for Graduate Credit.

ME 477 Composite Materials (3-0)3
[ME 395]

The course devotes attention to three basic areas of composite material technology, namely, analysis, fabrication, and applications. Micro and macromechanics of composite materials are considered and several fabrication techniques are considered for applications ranging from aircraft structures to fiberglass boats. May be taken for Graduate Credit.

ME 480 Advanced Projects in Systems and Design (1-6)3
[Senior Standing]

For the student desiring to carry on substantial projects of his own choosing in the areas of engineering design, systems or automatic controls. Special lectures and seminars to be arranged when appropriate. Projects arranged on an individual basis in consultation with instructor. May be taken for Graduate Credit.

ME 488 Environmental Conditioning (3-0)3
[ME 242 or ME 347]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces. May be taken for Graduate Credit.

ME 497 Automatic Control Systems (3-0)3
[EE 212, MA 302, ME 354]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 530 Ultrasound, A Nondestructive Evaluation Method (2-3)3
[MA 302]

Propagation characteristics of ultrasound are developed and analyzed to indicate usefulness as a nondestructive method of evaluation. Equipment for generation detection and display. Scientific and engineering applications using velocity and attenuation measurements are stressed.

ME 531 Advanced Thermodynamics (3-0)3
[ME 242]

A comprehensive treatment of the first and second law. Criteria of equilibrium, Multicomponent systems. Chemical reactions and chemical equilibrium, Maxwell relations, availability. Applications to selected topics.

ME 534 Transport Processes (3-0)3
[ME 343, MA 302]

Diffusive and convective transport of mass, momentum and energy. Free and forced convection in laminar and turbulent flows. High velocity flows, ablation, boiling and condensation.

ME 535 Advanced Heat Transfer (3-0)3
[ME 343, MA 302]

Conduction in steady and transient state problems. Solution by formal mathematics, numerical, graphical and analogy method. Thermal stresses. Basic laws of radiation; heat transfer between surfaces, absorbing media.

ME 541 **Advanced Fluid Mechanics** **(3-0)3**
[ME 382, MA 302]

Basic equations of motion of inviscid fluid. Irrotational flows, stream function and velocity potential. Complex potential, conformal transformations, streaming motions, sources and sinks. Vertical flow.

ME 542 **Advanced Gas Dynamics** **(3-0)3**
[ME 382, MA 302]

Equations of motion for inviscid, compressible fluid. One-dimensional steady flow with area change, friction, heat transfer and combustion. Shock waves. Unsteady flows and wave phenomena. Similarity, characteristics, small disturbances, approximation procedures.

ME 546 **Energy Conversion** **(3-0)3**
[EE 212, MA 302, ME 343]

Concepts of thermodynamics pertaining to energy conversion, irreversible thermodynamics. Solid-state phenomena involved in conversion processes; energy forms, equations of states, and energy fields. Selected topics in direct energy conversion systems.

ME 552 **Continuum Mechanics** **(3-0)3**
[ME 220, ME 242, MA 301]

Stress and deformation in a continuum in tensor notation. Fundamental laws of mechanics and thermodynamics. Applications to elastic, viscous and viscoelastic substances.

ME 554 **Theory of Elasticity** **(3-0)3**
[ME 473, ME 552]

Formulation of the problem of elastic equilibrium. Torsion and flexure of prismatic bars, contact stresses, plane stress, plain strain and stress concentrations.

ME 556 **Theory of Inelastic Continuum** **(3-0)3**
[ME 473, ME 552]

Development of the constitutive equations governing inelastic (aneleastic, viscoelastic, plastic and visco-plastic) deformations. Theorems and boundary valve problems as applied to inelastic continua.

ME 561 **Advanced Dynamics** **(3-0)3**
[ME 417]

Dynamics of mechanical systems by use of direct and variational methods. Three-dimensional rigid body dynamics, and

vibrations of lumped parameter and continuous systems. Nonlinear and self-excited oscillations. Stability.

ME 564 Structural Dynamics (3-0)3
[ME 417]

Response of complex structures to deterministic and random excitations. Exact and approximate normal modes by energy, and by differential and integral methods. Proportional and non-proportional damping.

METEOROLOGY

MY 205 Elementary Meteorology (3-0)3
[MA 104, PH 102]

Instantaneous and average distributions of pressure, temperature, water vapor, and velocity. Characteristic features of these distributions; waves, cyclones, anticyclones and fronts. Distribution of fog, clouds, precipitation, thunderstorms & tornadoes. Meteorological instruments & observations.

MY 206 Elementary Meteorology (3-0)3
[MY 205]

Heat balance & qualitative circulation theory. Elements of atmospheric thermodynamics & hydrodynamics: equation of state; first law of thermodynamics; hydrostatic equilibrium & its stability; the laws of large-scale motion; gradient, geostrophic & thermal winds.

MY 301 Atmospheric Dynamics (3-0)3
[MY 206]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium & its stability. Convection theory. The equations governing large-scale frictionless motion in the atmosphere. Steady state motion.

MY 302 Atmospheric Dynamics (3-0)3
[MY 301]

Unsteady motion: development of thermal circulations: barotropic & baroclinic conditions, circulation, vorticity & divergence; mechanism of pressure change; Sutcliffe development and elements of numerical weather prediction.

MY 307 Tropical Meteorology (3-0)3
[MY 206]

An introduction to tropical meteorology. Distribution of temperature, water vapor and velocity. Observations from aircraft, satellites and radar. Analysis of tropical data. Air sea interaction; convection and clouds. The trade wind region and intertropical convergence zone. Easterly waves and tropical storms.

MY 308 Synoptic Meteorology (2-3)3
[MY 206]

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network.

MY 403 Physical Meteorology (3-0)3
[MY 302]

Solar and terrestrial radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; radiative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion.

MY 413 Oceanography (3-0)3
[MY 302]

Physical properties of sea water. Distribution of pressure, temperature & salinity. Heat budget. Theories of wind-driven and thermal circulations. Transfer processes. Waves & tides. General circulation theory.

MY 415 Advanced Atmospheric Dynamics (3-0)3
[MY 302]

Perturbation theory of atmospheric wave motion. Numerical weather prediction techniques and models. Viscosity, turbulence and energy dissipation.

MY 416 Advanced Atmospheric Dynamics (3-0)3
[MY 415]

Diffusion in the atmosphere & meteorological aspects of air pollution. Stability of atmospheric circulations. General circulation theory & models.

MY 421 Analysis and Forecasting (1-6)3
[MY 302, MY 308]

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical

motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting.

MY 422 Analysis and Forecasting (1-6)3
[MY 421]

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures.

MY 430 Atmospheric Diffusion (3-0)3
[Permission of Instructor]

Study of the meteorological processes that affect the diffusion and removal of atmospheric pollutants: theories of diffusion and their application to the calculation of concentrations; the effects of buildings and topography on atmospheric diffusion; meteorological factors involved in the design and location of stacks.

NUCLEAR ENGINEERING

NU 201 Introduction to Nuclear Engineering (3-0)3

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission.

NU 202 Introduction to Nuclear Engineering (3-0)3

Utilization of nuclear energy. Nuclear Reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 305 Nuclear Instrumentation (2-4)4

The lectures are devoted to the design and operating characteristics of nuclear detectors and their use with electrometers, ratemeters, scalers, and pulse height analysers. The laboratory work is devoted to the characteristics of detectors and associated measuring circuits.

NU 306 Nuclear Instrumentation (2-4)4

The lectures cover the fundamentals of circuit theory as applied to pulse circuits. The laboratory work is devoted to the characteristics of tubes and transistors. Construction and operating characteristics of amplifiers and oscillators. Principles of

feedback and servo systems. Construction of pulse and digital circuits; binary circuits, mono and astable; trigger, coincidence and anti coincidence circuits.

NU 405 Nuclear Reactor Engineering (3-0)3

Neutrons, cross-sections and fission. Steady state and the criticality condition. Reflected, homogeneous and heterogeneous reactors. Fast reactors.

NU 406 Nuclear Reactor Engineering (3-0)3

Reactor control. Kinetics and reactivity effects. Control systems and instruments. Coolants and moderators. Fuels. Reactor operations.

NU 494 Advanced Nuclear Laboratory (0-6)3

Neutron activation experiments. Szilard Chalmer experiment. Measurements of slowing down lengths, diffusion lengths. Fermi Age. Effect of poisons in moderators as well as insertion of control rods. Experiments on reactor simulator including period measurements and effects of poison. Experiments on accelerator and reactor.

NU 495 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

NU 496 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Continuation of NU 495 for a second semester.

NU 497 Computer Programming and Applications I (3-2)3

Number systems, including binary, octal, and hexadecimal, and interconversions. General description of modern digital computer systems. Programming in Fortran IV and FOCAL languages. A detailed survey of the computer system software.

NU 498 Computer Programming and Applications II (3-2)3

Programming in symbolic assembly language. Introduction to systems programming. Applications of computer programming in nuclear engineering and physics problems, using both the FORTRAN IV and the assembly languages. The problems include numerical analysis techniques.

NU 505 Reactor Physics (3-0)3

Nuclear Reactions induced by neutrons: cross sections, fission; diffusion and slowing down of neutrons; Diffusion, Fermi Age and multi group treatment of unreflected and reflected homogeneous reactors, reactor design parameters.

NU 506 Reactor Physics (3-0)3

Reactor physics problems relating to the operation and kinetics of a nuclear reactor. Effect of poisoning, and temperature on design criteria; excess reactivity; elementary reactor kinetics, perturbation theory and control rod theory. Introduction to transport theory.

NU 507 Reactor Engineering (3-0)3

Analysis of fluid dynamics, heat transfer and thermal stresses as they influence the performance of a nuclear power reactor.

NU 508 Reactor Engineering (3-0)3

Engineering analysis of nuclear reactor systems including the interdependence of reactor physics, heat transfer, fuel management and power production. Economic considerations of nuclear power production.

PAPER ENGINEERING

PA 301 Engineering Analysis of Pulp Systems (3-0)3
[CN 204, PA 307 taken concurrently]

Lectures and problems concerned with the engineering design and technology of pulp manufacturing by commercial processes. Discussion of bleaching chemistry and the use of secondary fibers.

PA 302 Engineering Analysis of Paper Systems (3-3)4
[PA 301]

Discussion and study of engineering, design and economics of commercial methods of production of papers. Stock preparation; changes in physical and chemical properties of pulps; filling and loading of fibers; sizing, coloring and other additives. Material and energy relationships of various processes. Laboratory projects designed to illustrate principles expounded in lectures.

PA 307 Physical Testing and Data Analysis (2-3)3
[Approval of Instructor]

Fundamentals of the mechanical and optical testing of paper and allied products. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of testing. Structure of materials revealed by physical tests. Laboratory projects designed to illustrate problems involved in processing of pulp and evaluation of paper.

PA 403 Engineering Analysis of Converting (3-0)3
[PA 302]

Lectures and problems concerned with the engineering design, technology and economics of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials used for coatings. Mechanical, coating, impregnating, laminating and printing processes discussed in detail.

PA 405 Paper Converting Laboratory I (0-3)1
[PA 403 taken concurrently]

Development of converting techniques used with paper and paperboard. Use of Tappi Methods of evaluation. Emphasis is placed on colloidal and rheological properties of materials used in coating. Detailed written and oral reports.

PA 406 Pulp and Paper Systems Calculations (2-0)2
[PA 302]

Mathematical analysis of various processes encountered in the pulp and paper industry, using material and energy balances. Application of chemical engineering principles applied to various operations. May be taken for graduate credit.

PA 408 Paper Converting Laboratory II (0-3)1
[PA 405]

Special converting problems are studied in detail. Use of more specialized testing methods to evaluation coatings and other paper and paperboard converted products. Special emphasis is placed on the preparation of special converted products and the testing thereof. Oral and written reports required.

PA 410 Analysis of Paper Formation Process (3-0)3
[PA 302]

Discussion of the variables and factors involved in the formation of the paper web. Consideration given to fiber flocculation and orientation and to headbox design. May be taken for graduate credit.

PA 412 Polymeric Materials for the Paper Industry (3-0)3
[PA 302]

A study of the different types of polymers commonly used in paper manufacturing and converting. Chemical composition and properties of polymers. Properties of emulsions, solvent solutions, hot melts, extrusion coatings. Techniques of applications. Laminations with plastics and paper. Applications of combinations.

PA 417 Pollution Problems in the Paper Industry (3-0)3

Sources of pollution in the paper industry. Magnitude of disposal of effluents. Problems of the pulp manufacturer, the paper manufacturer and the converter. Techniques for controlling effluents and potential pollutants. Economic factors involved. Problems of recycle and future of this technique.

PA 419 Special Senior Projects Credits to be arranged
[Approval of Instructor]

Original research projects primarily in the field of paper engineering, supervised by a staff member. Reports required on work done.

PA 503-504 Advanced Converting Processes (3-0) (3-6)6
[PA 403, PA 408]

Specific converting processes. Analysis of coating processes (water-and solvent-based), extrusion coatings and hot metal coating. Latest techniques used by the converting industry involving mechanical and chemical operations. Engineering analysis of processes. Oral and written reports and plant visits.

PA 505 Physics of Paper (3-0)3
[Approval of Instructor]

Structures of fibers from a fundamental viewpoint and their effect on strength and other properties of sheets made from these fibers. Comparison of cellulosic and synthetic fibers. Engineering properties of fiber materials.

PA 506 New Techniques in the Paper Industry (3-0)3
[Approval of Instructor]

Lectures and discussion of new developments in engineering, design and application of physical and chemical principles in the manufacture of paper and paper products. Economic comparisons of new processes. Plant visits. Oral and written reports.

PA 507 **Fundamentals of Reprogaphy** **(2-0)2**
[Approval of Instructor]

An in-depth study of replicating and imaging systems from carbon paper, to xerography, to halography, covering theory and principles of operation, design and development of hardware and supplies, typical specifications and a cursory economic evaluation of these systems. Because of the unique technical character of this new field, a review of copyright, patents and trade secrets is provided. The current state of the art is reviewed and this potential represented by recent developments in the field is examined.

PA 509 **Economics of the Paper Industry** **(2-0)2**
[Approval of Instructor]

An evaluation of the paper industry from an economic viewpoint. Examination of costs and availability of different raw materials, additives and finishing materials. Analysis of competitive position of the paper industry and its products. Evaluation of foreign competition.

PA 512 **Advanced Fiber Processing** **(3-0)3**
[PA 302]

A study of fiber properties as related to fiber processing. Treatment of various theories of fiber processing. Discussion of mechanical treatments of fibers on the wet and dry properties of papers made from these fibers.

PHYSICS

PH 101 **Physics** **(4-1)4**

Mechanics: kinetics; dynamics — inertia, mass, momentum, force, impulse, application of Newton's laws, inertial and noninertial frames of reference.

PH 102 **Physics** **(4-2)4**
[PH 101 or equivalent]

Work, energy, rotational kinematics and dynamics, angular momentum, gravitation, elasticity, and simple harmonic motion. Temperature, ideal Gases, kinetic theory, thermal properties of solids and liquids, 1 and 2nd law of thermodynamics, Carnot cycle, entropy.

PH 201 Physics (4-2)4
[PH 102]

Elements of Electricity: electrostatics, fields, flux, Coulomb's law, electric potential, Ampere's Law, Faraday's Law and applications. Development of the lumped parameter circuit. Displacement current. Geometrical Optics.

PH 202 Physics (4-2)4
[PH 201]

Acoustical and optical wave phenomena, such as beats, Doppler Effect, reflection, refraction, interference, and diffraction; polarization; and spectra. Introduction to modern physics, atomic view of matter, Bohr theory of the atom, wave-particle duality.

PH 207 Mathematical Techniques of Physics I (4-0)4
[MA 104]

Techniques of approximate solutions of physical problems. Techniques of exact solutions of physical problems with applications to electrostatics, magnetostatics, and hydrodynamics, with appropriate mathematical background.

PH 208 Mathematical Techniques of Physics II (4-0)4
[PH 207]

Techniques of solutions of differential equations used in physics and engineering problems; in particular solution of the wave equation in bounded and unbounded media, with applications to electromagnetic phenomena and propagation of heat and sound.

PH 209 Physics (4-0)4
[PH 102]
[For physics majors only]

Same basic curriculum as in PH 201 with greater emphasis on field theory aspects. In addition, development of Maxwell's equations in integral differential form. Simple solutions and applications.

PH 210 Physics (4-0)4
[PH 211]
[For physics majors only]

Acoustical and optical Wave phenomena; reflection, refraction, interference, diffraction, polarization, Doppler Effect: group velocity Fourier analysis. Introduction to special theory of relativity; an atomic view of matter. Breakdown of classical mechanics.

PH 293 **Experimental Physics** **(2-6)4**
[Permission of Instructor]

Physical phenomena and methods used to observe and measure them. Elements of Circuit theory required for an understanding of measurements made with AC and DC instruments. Difficulties, limitations and interpretation of measurements. Demonstration of pertinent physical phenomena.

PH 294 **Experimental Physics** **(2-6)4**
[Permission of Instructor]

Continuation of PH 293 for the second semester.

PH 311 **Intermediate Mechanics** **(3-0)3**
[PH 208]

Kinematics of a single particle, and analysis of Newton's laws of motion, the mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, central forces, the mechanics of systems of particles from the points of view of Newton, Lagrange, and Hamilton.

PH 312 **Intermediate Mechanics** **(3-0)3**
[PH 208]

Generalized coordinates and moments, the Hamiltonian function, rotating rigid bodies, moments and products of inertia, principal axes, the theory of small oscillations, normal modes of vibration, and the vibrating string.

PH 335 **Modern Physics** **(3-0)3**
[PH 208, PH 212]

Black body radiation, Rayleigh, Jean's Law, Planck's law, photoelectric effect, X-rays, Compton effect, wave particle duality, DeBroglie waves, wave pockets, atomic structure, Rutherford model and Rutherford scattering. Bohr Model, Franck-Hertz experiments, correspondence principle, Bohr-Sommerfield model. Introduction to Wave Mechanics and quantum numbers. Pauli exclusion principle, and vector model of the atom.

PH 336 **Modern Physics** **(3-0)3**
[PH 335]

Elementary application of wave and quantum mechanics to natural phenomena. Electron spin, spectroscopic nomenclature. Zeeman effect. Stern Gerlach experiment. Applications to solid state and introduction to nuclear physics.

PH 353 Electromagnetic Theory (3-0)3
[PH 208, PH 211]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity.

PH 354 Electromagnetic Theory (3-0)3
[PH 353]

Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 363 Introductory Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 366 Intermediate Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neuton physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 393 Advanced Laboratory (0-6)2
[Permission of Instructor]

A laboratory course which accompanies the junior and senior courses in the department, and which may serve as a vehicle for undergraduate experimental research in selected fields of physics and for practice in exposition or in teaching.

PH 394 Advanced Laboratory (0-6)2
[Permission of Instructor]

Continuation of PH 393 for a second semester.

PH 423 Thermodynamics (3-0)3
[PH 208]

A macroscopic analysis of the behavior of thermodynamic systems including the following topics: thermodynamic equilibrium states, the concept of temperature, the first law of thermodynamics, real and ideal gases, the ideal gas temperature scale,

heat engines and refrigerators, the second law of thermodynamics, reversible processes, the Carnot cycle, the Kelvin temperature scale, the concept of entropy and its philosophical significance, pure substances, enthalpy, Helmholtz free energy, Gibbs free energy, Maxwell's relations, the TdS equations, and applications found in modern physics.

PH 424 Introduction to Statistical Mechanics (3-0)3
[PH 441, PH 423]

A continuance of PH 423, but a microscopic level and including the following topics: probability theory, the classical statistical mechanics of Gibbs, phase space, phase density, Liouville's theorem, the microcanonical, canonical, and grand canonical ensembles, the partition function, the statistical mechanical interpretation of the thermodynamic functions and laws, modifications required by quantum mechanics, the Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution laws, and applications of the theory to ideal gases.

PH 441 Introduction to Relativity and Quantum Mechanics (3-0)3
[PH 336, PH 312, PH 354]

Coverance of physical laws, Lorentz transformation, relativistic mechanics, tensor analysis, proper time, Minkowski force, particle collisions, relativistic electrodynamics, field tensor. Experimental basis for interference of particles and the uncertainty principle; postulates of quantum mechanics, operators hermiticity, commutativity, orthogonality of eigenfunctions.

PH 442 Introduction to Relativity and Quantum Mechanics (3-0)3
[PH 336, PH 312, PH 354]

First order perturbations of energy levels, harmonic oscillator, free particle, one electron atom, hydrogen fine structure, Pauli principle and atomic shell structure.

PH 461 Nuclear Physics (3-0)3
[PH 336]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay.

PH 462 **Nuclear Physics** **(3-0)3**
[PH 461]

Alpha decay theory, gamma emission, two nucleon systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471 **Solid-State Physics** **(3-0)3**
[PH 441]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption.

PH 472 **Solid-State Physics** **(3-0)3**
[PH 471]

Lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semi conductor crystals.

PH 495 **Special Research Problems** **(3-0)3**
[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 496 **Special Research Problems** **(3-0)3**
[Permission of Head of Department and Instructor]

Continuation of PH 495 for a second semester.

PH 505 **Mathematical Methods of Physics** **(3-0)3**

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differential equations and their classifications.

PH 506 **Mathematical Methods of Physics** **(3-0)3**
[PH 505]

Boundary value problems, Sturm Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

PH 507 **High-Energy Physics** **(3-0)3**
[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511 **Classical Mechanics** **(3-0)3**
[PH 312]

An analysis of the mechanics of systems of particles from the points of view principally of Newton, Lagrange, and Hamilton, including the following topics: Newton's laws, conservative and non-conservative forces, holonomic and nonholonomic constraints, Lagrange's equations, Hamilton's principle, orthogonal transformations, the motion of rigid bodies, rotating frames of reference, the rotation of a symmetrical rigid body.

PH 512 **Classical Mechanics** **(3-0)3**
[PH 511]

Hamilton equations, the principle of least action, canonical transformation, Poisson brackets, Hamilton-Jacobi theory, action and angle variables, and a comparison between classical mechanical and geometrical optics.

PH 515 **Quantum Mechanics** **(3-0)3**
[PH 441, PH 511 taken concurrently]

Wave pockets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum.

PH 516 **Quantum Mechanics** **(3-0)3**
[PH 515]

Spin, time-dependent and independent peturbation theory. Scattering theory.

PH 517 **Advanced Quantum Mechanics** **(3-0)3**

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory.

PH 518 **Advanced Quantum Mechanics** **(3-0)3**
[PH 517]

Second quantization and canonical commutation rules. Connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 521 Statistical Mechanics (3-0)3
[PH 424]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein.

PH 522 Statistical Mechanics (3-0)3
[PH 521]

Applications of statistical mechanical methods to thermodynamics, solid state physics, and nuclear physics.

PH 557 Electricity and Magnetism (3-0)3
[PH 208, PH 354]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity.

PH 558 Electricity and Magnetism (3-0)3
[PH 557]

Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561 Nuclear Physics (3-0)3
[PH 462]

Stationary states of nuclei nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles.

PH 562 Nuclear Physics (3-0)3
[PH 561]

Gamma rays and neutrons; nuclear forces and nuclear models; fast neutron physics.

PH 573 Quantum Theory of Solids (3-0)3
[Permission of Instructor]

Acoustic and optical phonons; plasmons; the Hartree-Fock approximation; many-body theory; electron-phonon interactions; the band theory of solids.

PH 574 Quantum Theory of Solids (3-0)3
[Permission of Instructor]

Metals; semiconductors; transport theory; neutron diffraction; superconductivity; magnetism, and magnetic resonances.

PH 575 Neutral Particle Transport (3-0)3

Boltzmann and integral transport equations, Spherical Harmonic, and variational methods. Correction to diffusion theory.

PH 576 Neutral Particle Transport (3-0)3
[PH 575]

Special methods and solving transport equations. Adjoint functions. Applications to physical systems.

PH 583 General Theory of Relativity (3-0)3
[Knowledge of Special Relativity]

Review of Newtonian gravitational theory and special relativity. Weak and strong principles of equivalence. Tensor analysis in Riemann spaces. Einstein's equations for the gravitational field.

PH 584 General Theory of Relativity (3-0)3
[Knowledge of Special Relativity]

Classic tests of Einstein's theory; spherically symmetric solutions. Gravitational field theory, and the canonical analysis of general relativity.

PH 593 Graduate Laboratory Credits to be arranged
[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 594 Graduate Laboratory Credits to be arranged
[Permission of Instructor]

Continuation of PH 593 for a second semester.

PH 942 Physics (3-2)4
[46.22]

Elements of electricity and magnetism: Coulomb's law, fields, Gauss' law, potential, current, dc circuits, magnetic fields and forces, induced emf, ac circuits.

PLASTICS TECHNOLOGY

PL 201 (2-2)3

A descriptive subject to acquaint the student with plastics as a class of materials. The history, classification, definition, raw

materials, methods of manufacture, properties and uses of polymeric materials. Introduction to laboratory methods in the processing and fabrication of plastics materials.

PL 202 Introduction to Polymeric Materials (2-2)3
[PL 201 or Permission of Instructor]

A continuation of PL 201. Emphasis is placed on the engineering thermoplastics. Polymers for thermal extremes as well as many of the newer high performance plastics are also discussed. Introductory laboratory instruction is continued.

PL 204 Process Control Systems (3-0)3
[PH 102 or Permission of Instructor]

Basic principles of control systems used with plastics processing equipment. Included are hydraulic, pneumatic, electromechanical, pressure and temperature control devices.

PL 301 Plastics Technology I (2-2)3
[PL 201, PL 202 or Permission of Instructor]

Analysis of additives including stabilizers, plasticizers, biocides, release agents, flame retardants, colarants and foaming agents as well as modifiers, fillers and reinforcing agents. Laboratory instruction of a more advanced nature in the processing and fabrication of plastics molding materials is introduced.

PL 302 Plastics Technology II (2-2)3
[PL 301 or Permission of Instructor]

Discussion of compounding techniques and the evaluation and development of typical plastics molding compounds. Survey of materials for reinforced plastics and composites, film and sheeting, adhesives, and non-plastics applications of polymers.

PL 401 Plastics Technology III (2-0)2

A theoretical and practical study of plastics process engineering. Correlation of composition, processing and fabrication with mold, product and equipment design.

PL 402 Plastics Technology IV (2-0)2

A continuation of PL 401.

PL 403 Physical Properties of Polymers (2-2)3
[Open to seniors only]

Introduction to basic mechanical properties of polymers as linear viscoelastic materials. Concepts of creep, stress relaxation, and superposition principles emphasized. Important material parameters are obtained in laboratory sessions.

PL 404 Physical Properties of Polymers (2-2)3
[PL 403]

Dynamic mechanical behavior, interrelations between various properties, electrical behavior, miscellaneous mechanical properties, optical properties.

PL 405 Methods of Polymer Characterization (2-0)2
[Open to seniors only]

Survey of physical techniques used in the characterization of polymeric materials with respect to molecular weight, molecular weight distribution, stereo regularity, branching, glass and other transitions, ordering, crystallinity, orientation, fine structure and cross linking.

PL 406 Polymer Structure (3-0)3
[Permission of Instructor]

The fundamental relationships between molecular structure, properties and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical composition, molecular size and flexibility, intermolecular order and binding, and supermolecular structure. Properties include processability, mechanical, acoustic, thermal, electrical, optical and chemical properties, price, and balance of properties. Applications include rigid solids, flexible solids, foams, films, and non-plastic applications.

PL 407 Plastics Industry Organization (3-0)3
[Permission of Instructor]

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing, and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit and growth.

PL 409 Senior Research in Plastics (1-6)3
[Permission of Instructor]

Individual research projects in plastics chemistry, properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs and submit final reports for publication.

PL 410 Senior Research in Plastics (1-6)3

Continuation of PL 409.

PL 411 Plastics Seminar (1-0)1

Informal discussions based on literature study conducted by the individual of topics in or related to Plastics Technology.

PL 412 Plastics Seminar (1-0)1

A continuation of PL 411.

PL 413 Senior Projects I (0-2)1

Assignment of senior projects designed to develop the student's ability to organize and conduct investigations of materials performance and processing techniques.

PL 414 Senior Project II (0-2)1

A continuation of PL 413.

RADIOLOGICAL SCIENCES

RS 100 Basic Radiological Health Physics 8 weeks
[Primarily for RS students]

Introduction to atomic and nuclear physics; natural and artificial radioactivity, radiation, decay schemes; nuclear reactions including fission and fusion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations; principles of radiation detection and detection devices; counting systems and assay of , ß, emitters; survey and monitoring equipment; external radiation exposure and protection techniques; internal radiation exposure and protection techniques; radiation safety and control.

RS 200 Applied Radiological Health Physics 8 weeks work experience
[Primarily for RS students]

Internship for eight weeks of applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 300 Applied Radiological Health Physics 8 weeks work experience
[Primarily for RS students]

Internship for eight weeks of applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 401 Principles of Radiation Safety and Control (3-0)3
[PH 363 or equivalent]

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material.

RS 402 Principles of Radiation Safety and Control (3-3)4
[PH 363 or equivalent]

A laboratory course giving students experience with equipment and practices of current use in the Radiation Protection Field, an extension of RS 401 giving the practical aspects of radiation safety and control.

RS 411-412 Research in Radiological Sciences 8
[Primarily for RS students]

A research problem related to the field of radiation protection is investigated by the student under the direction of faculty and staff of the Nuclear Center. The student will present a seminar on his research project. Areas of research anticipated include radiation shielding, radiation detection and measurement, radiation survey and monitoring, radiation biology, radiation chemistry, radiobiology, radiochemistry, radioecology, natural radioactivity, fall out, analyses and measurement of radioactivity and radiation levels associated with the operation of reactors and accelerators, and radioactive aerosols.

RS 422 Environmental Radiation and Nuclear Site Criteria (3-0)3
[Permission of Instructor]

Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, aquatic and terrestrial ecosystems; design and operation of environmental surveillance programs around nuclear facilities; reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations.

RS 431-432 Seminar in Radiological Sciences (2-0) (2-0)2
[Primarily for RS students]

Guest speakers and staff of the Nuclear Center present not only topics of current interest to the field of radiation protection but also descriptions of radiological health physics programs at

various nuclear and radiation facilities. Students present a seminar either on their research project or on their critical essay.

RS 441 Radioisotope Techniques (3-3)4

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Integrated into both laboratory and lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities.

RS 451 Introduction to Electronic Product Radiation (3-0)3
[Permission of Instructor]

The theoretical and applied aspects of the generation, measurement, and uses of radiant energy from electronic products whose emissions span the entire electromagnetic spectrum; ultrasonic energy emitted by electronic products; biological effects, standards of protection and control, and consequences and intent of Public Law 90-602.

RS 452 Electronic Product Radiation Laboratory (1-4)3
[RS 451]

A laboratory course aimed at practically demonstrating some of the more important principles and instrumentation used in the generation and measurement of electronic product radiation. Experiments involving the properties and measurement of radiation from lasers and microwave sources will represent a large portion of the course.

RS 501 Radiation Physics and Shielding Design (3-0)3
[Permission of Instructor]

Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding of point, surface, and volume sources; shielding design factors in reactor and accelerator operation.

RS 503 Introduction to Radiation Chemistry (3-0)3

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination.

SOCIAL SCIENCES

SS 223 The United States: 1865-1917 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

SS 224 The United States: 1918-1945 (3-0)3

A study of Politics and foreign policy from Wilson through Roosevelt.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 226 Europe: 1914 to the Present (3-0)3

A study of the period of the two World Wars and the postwar periods in which totalitarianism, new power alignments, and new international organizations developed.

SS 232 Social and Economic Change in Europe: 1750 to the Present (3-0)3

This course studies the impact of economic change on the life of Europe since the 18th century. After a brief survey of theories of development, the economic revolutions of the past 200 years are examined in depth. The relationships between economic change and social and intellectual life are also explored.

SS 235 England: Roman Times to the Restoration (3-0)3

The history of England to 1660 with emphasis on the development of the institutions of monarchy and Parliament, culminating in the clash between the two and the Restoration in 1660.

SS 236 England: The Restoration to the Present (3-0)3

England's history from the Restoration, tracing the rise of parliamentary government, the cabinet system, domestic reforms, and imperial policy.

SS 301 Government of the United States (3-0)3

A study of the political structure of the national government and the most crucial problems, domestic and foreign, that it is

facing today. Emphasis is given to the manner in which the American federal government is confronting these problems and their influence on American society.

SS 303 Psychology (3-0)3

An introduction to the basic principles of human behavior. The major areas covered include the origins and development of psychology as a science, the stages of human development, motivation and emotion, sensing and perceiving, the nature and management of learning, testing ability and intelligence, and neuroses and psychoses.

SS 305 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 307 Seminar in Sociology (3-0)3

[Limited to upperclassmen. Approval of Instructor required.]

Designed to assist the advanced student with the proper sociological concepts and insights as they apply to the social settings in business and industry. The core objective is the development — through the case method — of the balance between skill and knowledge and their application in sound technical and administrative decisions affecting individuals and groups within organizations.

SS 308 Psychology of Interpersonal Behavior (3-0)3

A study of the science of interpersonal behavior and of the development of theories of the personality. Major topic areas discussed include: the meaning and measurement of interpersonal behavior, behavior development, personality development, conflict and anxiety, defense and coping mechanisms.

SS 322 Moral Problems in a Technological Age (3-0)3

The course will deal with contemporary social issues such as, war and peace, prejudice and race relations, inter-faith tensions, changing sexual patterns, and ecology.

SS 340 The United States: 1945 To The Present (3-0)3

An historical study of the United States since World War II.

SS 352 Contemporary Political Theory (3-0)3

An examination of contemporary political theory and its relation to current social problems.

SS 362 Social Psychology (3-0)3

A seminar involving the problem of social order, the socialization process, social interaction, and the maintenance of social order.

SS 371 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in the United States. Emphasis is given to the economic, political, and social which were causing the simultaneous growth of the sectionalism that led to the Civil War.

SS 451 History of France (3-0)3

The History of the development of ideas and institutions in modern France from the age of absolutism through the mid-**twentieth century.**

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles have been applied by the United States are examined through case studies.

SS 472 National Security Policy (3-0)3

A study of the relationship of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of natural security.

SS 474 Cultural Anthropology (3-0)3

A seminar analyzing various living societies and their cultures in terms of social adjustment to recurring needs.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U. S. S. R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviety state; the Stalinist period; and current domestic and foreign problems.

SS 482 The United States: Urban History (3-0)3

Social, cultural, economic, and political factors in the formation and development of the modern American city.

SS 483 The Development of Western Civilization: To 1789 (3-0)3

The history of the development of ideas and institutions from democratic Athens to the absolutism of Louis XIV.

SS 484 The Development of Western Civilization: Since 1789 (3-0)3

The development of ideas and institutions from the age of absolutism to the mid-twentieth century.

SS 485 Modern Governments of Europe (3-0)3

A study of the institutions and politics of the United Kingdom, France, Germany, and the Soviet Union.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 489 Political Parties in the United States (3-0)3

A study of voting behavior, policy making, and the historical development of American political parties.

SS 494 England: The Empire Since 1793 (3-0)3

A study of British foreign policy and the development of the Empire from the Napoleonic Wars to the formation of the present Commonwealth. Against a background of domestic social, economic, and political changes, the course will stress the British parliamentary system and its influence on other nations.

SS 495 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles" — the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 496 The Technological Future: The Social and Political Aspects (3-0)3

Lectures and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 497 Tutorial: History or Political Science (3-0)3
[Permission of Instructor]

Independent directed study under the guidance of individual members of the department.

SS 501 Afro-American History (3-0)3

An historical study of the patterns of racial relations and the participation of Afro-Americans in the social, economic, political, and cultural life of the United States. The topics covered include the origins and development of the slave system, the Civil War and Reconstruction, urbanization, the Civil Rights movement, and "Black Power."

SS 504 Technology and Social Change (3-0)3

An examination of the historical impact of Technology on man and society.

SS 505 Technology and Society (3-0)3

An examination of the impact of technology on contemporary man and society.

SS 528 Social Ecology (3-0)3

This course provides the student with an exposure to man's interrelationship with his total environment and its effects on social behavior.

TEXTILES ENGINEERING

TE 211 Chemistry and Physics of Textile Fibers (3-1)3
[Offered both Semesters]

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-

strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 263 Textile Systems I (3-1)3

The preparation into yarn of staple cellulosics and man made fibers on the cotton system as well as filamentous man made fibers. These are presented analytically in terms of engineering principles or mechanisms concerned with functional use, structural design, and basic geometry of the yarns.

TE 264 Textile Systems II (3-3)4
[TE 263]

Same as TE 263 but involving wool in woolen or worsted yarn systems or blends of same with natural and synthetic fibers. A consideration of recovery processes for use of waste in varied fabrics is included.

TE 331 Textile Systems III (3-1)3
[TE 264]

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 332 Textile Systems IV (3-3)4
[TE 331]

A study of the more complex woven structures including dobby, jacquard, multi box looms, double fabrics, etc. This subject also covers the various types of shuttleless looms presently available.

TE 403 Modern Trends in Fabric Production (2-2)3
[TE 332]

The production and utilization of non-woven, needlepunched and stitch bonded fabrics are discussed in detail. The utilization of waste or unique processes for the production of yarns, fabrics and allied products are also covered.

TE 433 Technology of Knitting (2-3)3

A study of the principles of knitting and the mechanisms required to develop various fabric structures. Topics included are programming systems, pattern wheel designing, double knits, warp knitting, basic tricot designing and knit fabric geometry.

TE 434 **Advanced Knitting** **(2-3)3**
[TE 433]

A detailed study of engineering principles involved in knitting action with an analysis of jaquard systems, knit çam design and warp knitting mechanisms.

TE 459 **Textile Systems V** **(3-0)3**
[TE 332]

A study and analysis of the physical behavior of gray fabrics to mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved.

TE 460 **Textile Systems VI** **(1-2)2**
[TE 459]

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 472 **Textile Evaluation** **(2-3)3**
[TE 332, MA 383]
[May be given each semester]

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 **Instrumentation for Textiles** **(2-2)3**
[PH 102]

A study of some mechanical, electrical, and electronic methods for the measurement and control of such common textile process variables as pressure, temperature, liquid level, and fluid flow. The response of sensing elements, the modes of control, the characteristics of final control elements, and the interrelationship between those in closed loop systems are considered.

TE 482 Application of Scientific Methods to Textile Processes (3-0)3
[PH 201, MA 203, ME 216]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483 Engineering Design of Textile Structures I (3-0)3
[MA 203, TE 332]

This subject correlates engineering properties of textile materials, engineering principles and textile methods in the design of textile structures with desired properties. Considered, are the following: the geometry and design of yarns for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes imposed by end use; and analyses of load-elongation diagrams of fibers and yarns.

TE 484 Engineering Design of Textile Structures II (3-0)3
[TE 483]

This subject deals primarily with three dimensional textile structures. The concept and objectives of the course are similar to that of TE 483. In addition, metallic fabrics and graphical solutions are considered.

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1972-1973

DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Dean of Admissions
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Official transcripts	Registrar
Graduate studies	Dean of Graduate School
Summer school	Director of Summer School Director of Continuing Education
Evening study program	Director of the Evening Division
Alumni affairs	Alumni Office
Graduate placement	Placement Director
Library industrial corporate membership	Librarian
Conferences, special programs, public relations	Director of Public Relations
Sponsored research	Lowell Technological Institute Research Foundation

LOWELL TECHNOLOGICAL INSTITUTE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

Day programs leading to B.S., B.S. in B.A., M.S., and Ph.D. degrees

Evening programs leading to A.B.M., A.A.S., A.S., and A. Eng. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineer's Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

Total enrollment — 8670
Undergraduate Colleges — 3256
Evening Division — 3194
Summer School — 1775
Graduate School — 445

Men and women students from 20 states and 30 countries

Tuition: $250 for U.S. citizens who are residents of Massachusetts; $850 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

The main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River, one half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 a.m. — 5:00 p.m., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

* * *

The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein, and to change any of the subjects or curricula, or portions thereof, without prior notice.

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ACADEMIC CALENDAR, 1972-1973

First Semester

August 28, Monday	Freshman and Graduate Student Testing Begins
August 31, Thursday	Transfer Students Register
September 1, Friday	Sophomore Students Register
September 5, Tuesday	Junior and Senior Students Register
September 5 and 6, Tuesday and Wednesday	Graduate Students Register
September 6, Wednesday	Freshman Students Register
September 6, Wednesday	Classes Begin, Upperclassmen
September 7, Thursday	Classes Begin, Freshmen and Graduate Students
October 9, Monday	Institute Closed (Columbus Day)
October 11, Wednesday	Monday Schedule of Classes
October 23, Monday	Institute Closed (Veterans Day)
November 22, Wednesday, 6 p.m.	Thanksgiving Recess Begins
November 27, Monday	Classes Resume (Last Day to Drop Courses)
December 15, Friday	Classes End
December 16, Saturday	Examinations Begin
December 22, Friday	Semester Ends

Second Semester

January 15 and 16, Monday and Tuesday	Registration of Students (graduates and undergraduates)
January 18, Thursday	Classes Begin
February 19-21, Monday-Wednesday	Washington's Birthday Recess (no classes)
February 19, Monday	Institute Closed
February 22, Thursday	Classes Resume
March 9, Friday	Wednesday Schedule of Classes
April 5, Thursday	Tuesday Schedule of Classes
April 13, Friday, 6 p.m.	Spring Recess Begins
April 23, Monday	Classes Resume (Last Day to Drop Courses)
May 11, Friday	Classes End
May 14, Monday	Examinations Begin
May 19, Saturday	Semester Ends
May 27, Sunday	Commencement

Normally, classes are held from 8 a.m. to 6 p.m., Monday through Friday. This calendar is subject to change.

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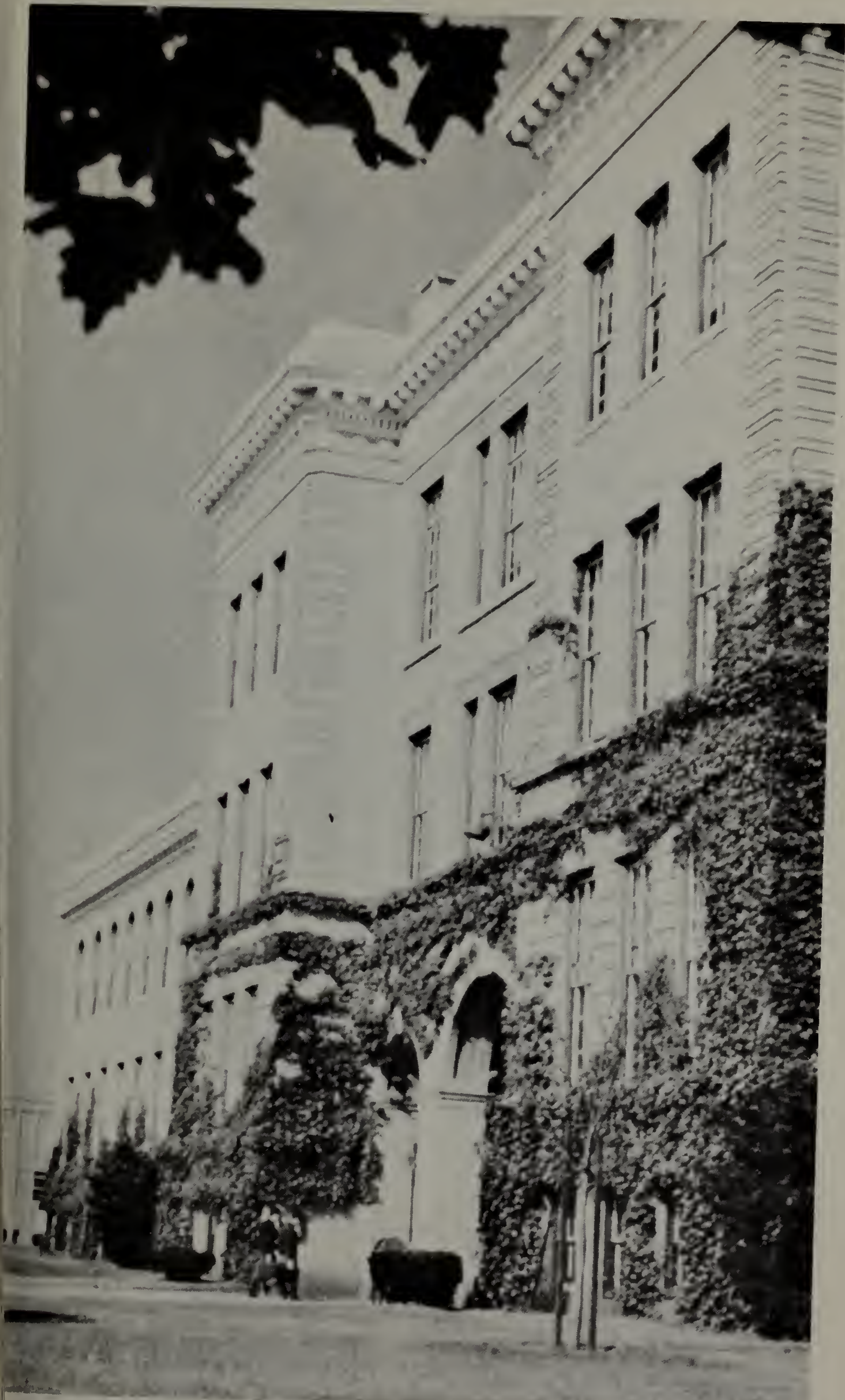

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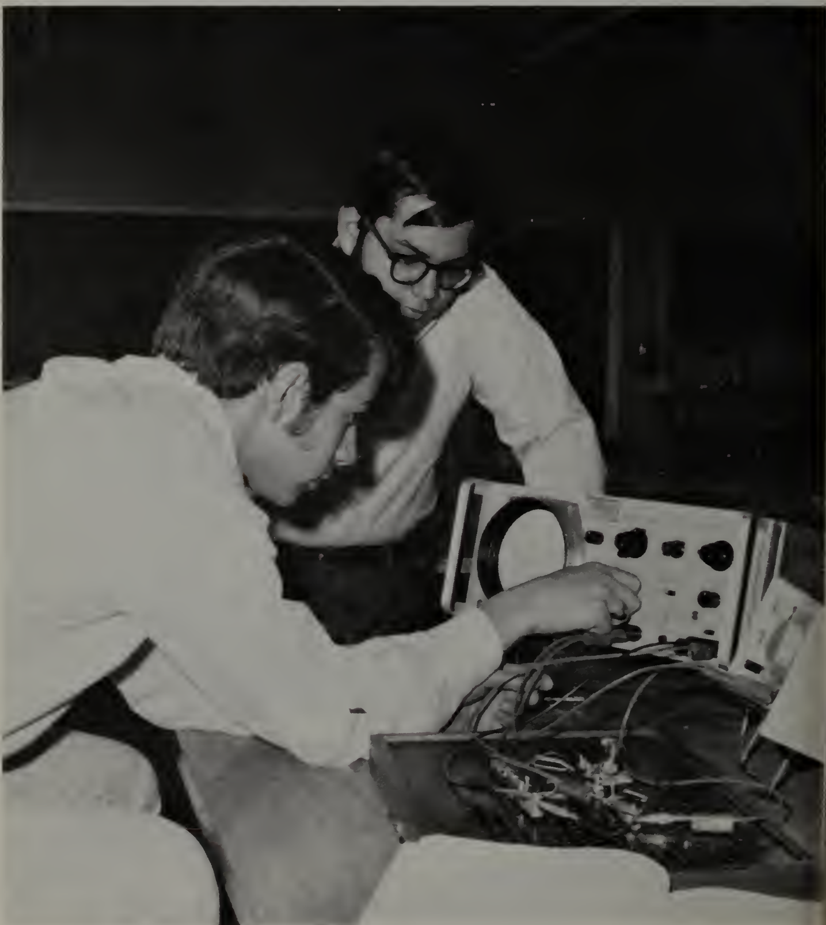

GENERAL INFORMATION

History and Aims

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 is was granted the right to confer four-year degrees in textile engineering and textile chemistry. In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, radiological science, physics, mathematics, nuclear engineering, industrial management, business administration, meteorology, and biological sciences. In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to Lowell Technological Institute. The Institute grants Bachelor of Science, Master of Science, Master of Management Science, and Doctor of Philosophy degrees. Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

The major aims of Lowell Technological Institute are to furnish sound educational programs in science, engineering, technology, business and management at both the undergraduate and graduate levels to cultivate in its students a professional attitude in their fields of concentration and to develop their ability for creative thinking. All education, and particularly in the fields of study offered at the Institute, must be based on a thorough grounding in the fundamentals upon which the study in the area of specialization is built; but, it must prepare the student for life in general and thus there must be an emphasis on the development of self-reliance and awareness of the interrelation between science, technology and industry and the society in which we live. For this reason, all curricula have a balance of basic material leading into more advanced theoretical and applied treatment of this knowledge with the inclusion of sufficient humanities to make a meaningful education for a productive life. Graduates are prepared to enter industry in the fields they have chosen or to continue for further education in graduate schools in preparation for research, teaching, or industrial positions.

Accreditation

The Institute is a member of the New England Association of Schools and Colleges. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in chemical, electrical, mechanical, and textile engineering. The ECPD has also accredited a two-year part-time program in civil engineering technology and a four-year part-time program in civil engineering technology. The chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus

The campus is situated 25 miles north of Boston, on the banks of the Merrimack River in Lowell, a city of 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 60-acre campus includes 16 main buildings, among them a large modern library, a nuclear center and a fine gymnasium. Currently under construction is an 18-story student-union building, a $12,000,000 chemistry building and an arts and science building. Scheduled for immediate construction is a $2 million parking lot with a 3000 car capacity.

Alumni Memorial Library

The library, dedicated to Alumni of the Institute who served in World Wars I and II and the Korean conflict, has recently undergone an extensive expansion. The original building, constructed in 1951 by the Alumni Association, now houses the library's rare books, government depository collection, technical reports and a ground floor student activities area. The new addition, which is linked to the original building by means of ramps, houses most of the library functions. The main floor contains the lobby with its control desk, exhibition area, catalog, reserve book room, reference room as well as the administrative and work areas for the library staff. Two elevators serve the library building. The third floor houses the extensive periodical collections, including current issues as well as a microprint area. A section of this floor holds the abstracts and indices that serve as a guide to the periodical collections. The fourth floor houses the science and technology book collection while the fifth floor

houses the collection of the humanities and the social sciences. On each floor shelving areas are mixed in with reading and lounge areas to give maximum accessibility to our collections. The longe areas on the upper floors provide excellent views of the City of Lowell and the surrounding areas. The ground floor has a complete audio-visual area consisting of a master control room, a student listening room with thirty-one individual stations, six individual listening areas with equipment, an audio-visual office, a multi-purpose room seating 140 and a nine room radio station complex. The building seats approximately 1000 students and has a stack capacity of 450,000 volumes. A walkway under the side of the building adjacent to Smith Hall leads to the first aid station and the dormitory areas located behind the library.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $20,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Dean of Admissions Office has received senior grades for this period. The responsibility of having these grades forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure no less than 12 months in advance of the expected date of enrollment.

The Institute does not accept part-time or special students, nor does it accept students at mid-year.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Dean of Admissions, Lowell Technological Institute, Lowell, Mass. 01854.

Applications for admission are preferred by the Institute on or before April 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is requesting financial assistance must file a Parents' Confidential Statement with the Institute.

Application Procedure

A candidate for admission to Lowell Technological Institute in any of the fields of study open to undergraduates must:

1. Complete the first two pages of the admissions application form and the attached STUDENT DATA SHEET.
2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.
3. Submit the entire application form to the office of the secondary-school principal or guidance director with a request that the office fill out the remainder of the application form and mail it directly to the Dean of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the SAT Test during the period of April of the Junior year through March of the Senior year in secondary school. Letters, telephone calls, etc., will not be accepted in place of the official score card.

6. Applicants must indicate their chosen major field of study in the proper space provided on pages 1 and 5 of the application.

7. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute a cerificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

8. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

9. The Institute requires the prepayment of 50% of the first semester's tuition within 12 days of the date upon which the applicant is accepted. For Massachusetts residents this amounts to $50.00. The prepayment is refundable if the student notifies the Office of Dean of Admissions in writing on or before June 1, that he does not intend to enroll. Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving a final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation. The responsibility for sending this final transcript to the Dean of Admissions Office rests with the student. Failure to instruct his secondary school to forward this final transcript could result in his being not accepted in the fall.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus Days. Personnel from the Dean of Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on October 27, 1972, January 26, 1973, and March 9, 1973 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must have been enrolled in a college preparatory program and must be a graduate of a secondary school approved by the New England Association of Colleges and Secondary Schools, Inc., the Regents of the State of New York or a board of equal standing.

The New England Association of Colleges and Secondary Schools accredits schools and colleges in the six New England states. Membership in one of the six regional accrediting associations in the United States indicates that the school or college has been carefully evaluated and found to meet standards agreed upon by qualified educators. Colleges support the efforts of public school and community officials to have their secondary school meet the standards of membership.

2. For all courses except Business Administration and Industrial Technology a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiencies in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration and Industrial Technology a candidate must have completed 16 units of approved high school work:

English	4 units
mathematics	2 units

American history and social studies	2 units
laboratory science	1 unit
electives	7 units

Advanced Placement

Lowell Technological Institute subscribes to the Advanced Placement Program of the College Entrance Examination Board which provides academic credit and placement for students who qualify. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have not completed two years of English in United States schools must take an English Proficiency Test, and have results sent to the Dean of Admissions, Lowell Technological Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U.S.A. and, as stated above, request the results be sent to Lowell Technological Institute.

The **TOEFL Bulletin of Information** and Registration Form can be obtained in a number of cities outside the United States. They often are available at one of the following: American Embassies and Consulates, Offices of the United States Information Service (USIS), United States Educational Commissions and Foundations abroad, and Binational Centers. In addition, several private organizations distribute TOEFL bulletins, among them (1) the Institute for International Education (IIE) in Nairobi, Kenya; Kowloon, Hong Kong, Paris, France; and Lima, Peru, (2) the African-American Institute in Dar es Salaam, Tanzania; and Lagos, Nigeria, (3) the American Friends of the Middle East in Tehran, Iran; Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt, (4) the American-Korean Foundation in Seoul, Korea, and (5) the Bureau of Educational Research at Ewing Christian College, Allahabad, U.P. India.

Students who cannot obtain a TOEFL bulletin and registration form locally should write well in advance for them to: Test of English as a Foreign Language, Box 899, Princeton, New Jersey 08540, U.S.A. Students residing in Taiwan must apply to: Language Center, 2-1 Hsu-chow Road, Taipei, Taiwan (100), for the Special Taiwan editions of TOEFL publications.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the

admission procedure for foreign students is the same as that required of U.S. citizens. They are urged, however, to have the transcript of their secondary school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U.S. students.

Transfer Credit Guidelines

A. A prospective student who wishes transfer to Lowell Technological Institute must indicate the curriculum major he intends to pursue. Because of space requirements, Lowell Technological Institute reserves the right to limit assignment of transfers to specific curricula.

B. A student must place on file the following credentials:

1. Application (including all six pages).
2. Letter of recommendation from transferring Institutions.
3. High School record.
4. College transcript (all colleges attended).
5. TOEFL (if required).
6. S. A. T. (if required).

C. A student must complete a minimum of one-year (2 semesters; 3 trimesters) at an approved Junior College, Technical Institute or 4 year College.

D. The applicant must have an academic cum average of 2.00 or above in order to qualify for a transfer status.

E. A College, in order to qualify for transfer status, must offer at least the Associate Degree.

F. The transfer application must arrive at Lowell Technological Institute prior to April 1st.

G. Credit will not be considered in subjects where applicants grade is lower than "C" range.

H. Students completing the equivalent of one full year of college work, the S.A.T. Examination requirement is waived.

I. One full year of Physical Education completed at another Institute will be considered for transfer credit. This subject is a degree requirement at L.T.I.

J. The following are the Credit requirements for Academic Classifications:

Freshman	0 to 23	Credits
Sophomore	24 to 55	Credits
Junior	56	Credits

It should be noted that the classification of Sophomore or Junior does not remove the course requirement of the preceding classification. Example: A student with 58 credits and classified as a Junior may be required to take Freshman Chemistry if he has not taken it or has not received credit for it.

NOTE:

International Students are advised that unless they have completed two years of college level work in the United States at an accredited College or University, they must fulfill the CEEB, S.A.T.'s and the TOEFL requirements.

Students who are not U.S. citizens and who are not immigrants, must obtain permission from U.S. Immigration and Naturalization Service to transfer from one educational institution to another. Permission should be obtained AFTER receiving admission as a transfer student.

GED Certificate

In order to encourage and support non high school graduates in their effort to obtain a college education, Lowell Technological Institute recognizes the GED TEST as an instrument to obtain the Massachusetts High School Equivalency Certificate which we in turn honor in lieu of a high school diploma. This applies to applicants from the state of Massachusetts only, and students applying from other states should consult their Department of Education regarding how the GED Certificate is used as an equivalent to a high school diploma.

New England Regional Student Program (N.E.R.S.P.)

Students who are legal residents of any one of the other five New England States may be eligible for consideration under this program. State Universities in New England offer certain undergraduate curricula to students from other New England States who cannot obtain a particular curriculum at their own State University. See your high school Guidance Counselor or write to the New England Board of Higher Education, 20 Walnut Street, Wellesley, Mass. 02181, or the Dean of Admissions, Lowell Technological Institute for further details.

Civil Rights Compliance

Lowell Technological Institute adheres to the terms of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) entitled "Nondiscrimination in Federally Assisted Programs," which states:

"No person in the United States shall, on the ground of race, color or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

STUDENT HOUSING AND SERVICES

Residence Halls

The LTI campus is oriented to a program that recognizes the educational advantages of both classroom instruction and extra-curricular activities. Residence hall living provides valuable exposure in this regard. Consistent with this philosophy, it is the policy of the Board of Trustees that all non-commuting students are required to live in the residence halls on campus insofar as our facilities permit unless excused by the Dean of Students. Excuses are reviewed periodically and may be cancelled should conditions warrant.

For purposes of implementing the above policy a commuting student is defined as one who commutes to and from the Institute on a daily basis while residing at home with parents or guardian.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students. When permission is granted to live off campus, the students must record, in the Dean of Students office, their off-campus local address. Further, the students are obliged to notify the Dean of Students office of any subsequent change during the academic year.

A list of off-campus rooms and apartments is provided, upon request, by the Housing Office to students who have been accorded permission to occupy other quarters.

Rooms are contracted for the full academic year EXCLUSIVE OF PERIODS WHEN THE INSTITUTE IS IN RECESS. Students are not permitted to remain in the residence halls during periods when the Institute is not in session. The Institute is not responsible for providing housing accommodations during vacation periods. Those students who cannot travel home during these periods must make their own off-campus arrangements for housing. No resident student is permitted, at any time, to maintain housing other than his residence hall assignment.

Upperclassmen are given choice of rooms and roommates in the spring of each year. Incoming freshmen are assigned dormitory space by the Housing Office in the order in which application data sheets are received.

Residence hall facilities are available for the housing of female students. Because of the increasing number of women in attendance at the Institute, spaces in these halls must be assigned on a priority basis. Applications will be processed in order of receipt.

Room assignments in residence halls are made for the academic year except as above noted. A change of rooms is not permitted except in rare instances and may be accomplished only after formal application is made to the Resident Advisor and approved by the Housing Office.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each occupant of a room is responsible for damage to furniture, equipment and interior surfaces. In the event of damage to public areas (corridors, lobbies, shower rooms, etc.) the cost will be apportioned among all residents of the building concerned.

It is the responsibility of each resident student to make arrangement for sheets, pillow cases, towels, blankets, pillows, etc., by subscribing to the linen service provided to all resident students at a nominal fee; or to supply these items himself, in which case he is responsible for the laundering thereof. Machines are provided in the various buildings for this purpose.

Room rental charge of $500.00 per year is payable on or before August 15 or, in the case of late acceptance, within fourteen days of receipt of bill.

Dining Halls

All students living in the residence halls are required to purchase a dining hall meal ticket. The Leitch Hall dining room is for the use of Bourgeois and Leitch Hall residents. Residents of Smith Hall, Eames Hall, and the Annexes will obtain their meals in the Smith Hall dining room. The contract food service provides two meals a day (breakfast and dinner), seven days a week, at a present cost of $204.50 per semester.

An alternate meal plan is available which provides the same two meals Monday through Friday at a cost of $195.00 per semester.

Refunds

In the event of withdrawal, a refund may be made only when the following conditions are met:

1. All rooms must first be assigned.
2. When another student of LTI (not originally assigned a dormitory room) takes up new residence in the dorm then a refund may be made to a withdrawn student in the order in which the withdrawal took place without regard to a specific room or space.

The Institute reserves the right to reassign rooms or to transfer resident students within the residence halls. In the event of such reassignment of a room or transfer of a student alreadv in

residence, the Institute shall not be liable for a refund to the former occupant of the room so reassigned or to which said transfer is made. In conjunction with the above, the cost of a dining hall meal ticket is refundable in accordance with the Tuition Refund Schedule.

Residence Hall Counseling

The counseling staff of each residence hall is supervised by the Resident Advisor and coordinated by the Dean of Students. They are responsible for the counseling, education, athletic, and social programs in the residence halls.

Under the guidance of the Resident Advisor, the floor counselors lend assistance and support to the development of interest in a strong responsible and active student organization. This necessitates imagination, skill, and initiative action on the counselors' part.

The entire residence hall staff assists the students, individually and collectively, in their orientation to resident hall life and communicates the philosophy that their total living and academic environment will be no better than the sincere contribution each of them makes to it.

The counseling staff is of great assistance to freshman resident students in familiarizing them with the various clubs, organizations, educational and cultural programs available at the Institute. With proper direction, extra-curricular pursuits can be a meaningful part of the student's total education.

Applications for residence hall counseling positions are accepted early second semester for the following year. Each applicant will be interviewed by a Resident Advisor and the Assistant Dean of Students, Residence Halls. All applicants will be notified of the results of their application prior to the end of second semester.

Residence Regulations and Advice

These are general guidelines offered for the good of all resident students. Areas not concerned in these guidelines must be cleared through the Resident Advisor and the Dean of Students Office.

Room Conditions:

You will find that your room is already equipped with desks, desk chairs, beds, mattresses, mirror, dresser and closet. You should bring a study lamp and an alarm clock. You may bring rugs, window drapes, bed spreads, etc.

Damages:

The Institute holds each student responsible for damage to property beyond normal wear and tear. Breakage or marring of furniture, defacing of walls, ceiling or floors, damage to windows, screens, or general vandalism to Institute property will result in a damage charge. Pictures may be taped to cement walls, and wood paneling; never to plastered walls. The use of nails or tacks on walls, woodwork or furnishings are prohibited.

Equipment Restrictions:

Cooking appliances, hot plates, and refrigerators are prohibited. Electrical appliances such as radios, phonographs, clocks, electric shavers, tape recorders, coffee pots, irons, are permitted. Upperclassmen may have televisions.

Room Maintenance:

For health and safety reasons, students should make beds daily, sweep floors, dispose of all trash and unplug electrical equipment when not in use. Cleaning equipment and light bulbs may be obtained from the custodian. Screen must be kept intact on windows and ledges kept clear — nothing may be hung from the windows.

Ironing:

Electric irons may be used only in laundry rooms and service rooms provided for this purpose.

PROHIBITED:

In the best interest of the student himself, his fellows, and the Institute, the following are prohibited:

1. Drugs: Students shall not bring into the dormitories, possess or store within the dormitories, marijuana, hallucinogens, barbituates, amphetimines and/or any other dangerous, illicit or illegal drug.
2. Firearms, explosives, chemicals: Students shall not possess firearms, weapons, fireworks, gunpowder, chemicals or any other type of explosive in the dormitory at any time.
3. Pets: Students shall not keep pets in the dormitories and pets are prohibited on campus.
4. Incense: Burning of incense and/or other offensive materials is strictly prohibited.
5. Automobiles: Freshmen resident students are not permitted automobiles.
6. Food: All food and utensils are not allowed out of the dining halls.

ALCOHOL: Subject to the laws of the Commonwealth of Massachusetts governing the acquisition, possession, transportation and consumption of alcoholic beverages and subject to the regulations adopted by the Board of Trustees, resident students of legal age (twenty-one years in Massachusetts) are permitted the possession and consumption of alcoholic beverages in specifically designated areas of the upperclass dormitories. A copy of the governing regulations is posted in each residence hall.

Food:

Non-perishable food items are permissible if stored in suitable containers. Perishable items must be consumed within 24 hours. The Institute bans the use of hot plates.

Loss:

It is understood that the Institute assumes no responsibility for loss or theft of or damage to any property belonging to residents. Individuals are therefore urged to exercise prudence in securing their property and the Institute advises that each student carry personal property insurance. Rooms should be kept locked at all times when vacant.

Solicitation:

Only L.T.I. Clubs and Organizations or L.T.I. students may solicit if authorization from the Dean of Students is given.

Bulletin Boards and Notices:

Residents are held responsible for information contained in notices on Bulletin Boards. Notices may pertain to special meetings, room sign-up, registration, etc. Permission to post other notices must have the Resident Advisor's approval.

Visiting:

The Board of Trustees in April, 1970, enacted co-ed visiting hours and set certain guidelines that must be followed. This policy was enacted on a temporary basis to be evaluated at a future date. The Institute can expect a more permanent, all inclusive policy as a result of student-administrative committee recommendations.

Noise:

Students are reminded that they live under group conditions and that acts of thoughtlessness and irresponsibility jeopardize the opportunities of everyone to study and work in the residence halls. Noise should be kept to a minimum. When in doubt, be considerate of other persons.

Evacuation Procedure:

In case of an emergency, i.e., fire, bomb scare, etc. turn **on** room lights, close windows, and leave room with door closed, then walk to the nearest exit. During emergencies, the building MUST BE EVACUATED.

Inspection:

Rooms may be inspected by Institute officials or counselor staff when considered in the best interest of the Institute.

First Aid:

The hours of the First Aid Dispensary, located behind the Library, are from 8:00 a.m. to 5:00 p.m. Report any illness or injury occurring at any other time to a member of the counseling staff.

Keys:

Keys are provided for each room. If lost, report to your floor counselor. Replacement fee is $2.00.

Health Service

Registered nurses are on duty for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with a parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance is also available, on a voluntary basis, through the Office of the Dean of Students.

Counselling

The counselling program, under the supervision of the Dean of Students Office, starts with the admission procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Director of Stu-

dent Counselling for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Director of Student Counselling.

Due to the increasing numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the counselling program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Counselling in the upper classes is generally conducted in scholastic matters by the Head of the Department concerned and in personal problems by the Dean of Students office.

A Foreign Student Adviser is available for counselling regarding problems relating to students from other countries.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE $10

1. The Institute requires the prepayment of 50% of the first semester's tuition within 12 days of the date upon which the applicant is accepted. For Massachusetts residents this amounts to $50.00. The prepayment is refundable if the student notifies the Office of Dean of Admissions in writing on or before June 1, that he does not intend to enroll.

2. The application fee is NOT credited to the student's tuition.

TUITION **(per year)**

U. S. citizens who are residents of Massachusetts **$200**

Participants in the New England Board of Higher Education Regional Student Program **$200**

All others **$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U.S. citizens who are residents of Mass. ... **$10.00 per cr. hr.**

All others .... **$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.

2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.

3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.

4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.

5. The residence of a wife follows that of the husband.

6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.

7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.

8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

ROTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND $60

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

Residence Halls .... **per year $500**

Each resident student will be billed for the entire academic year. In the event a student withdraws or is dropped at any time during the year, he is still responsible for the room charge and will be reimbursed only under the conditions as set forth on page 22

DINING HALL FEE — 5 Days .... **per year $390**
7 Days .... **per year $409**

LATE REGISTRATION FEE **$25**

A student who does not complete his registration (including the payment of all fees) by the close of the registration day assigned must pay this additional fee.

AUDITING FEE .... **$5/credit hour**

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE **$25**

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES **$5**

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE **$1/copy**

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But Less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition	
U.S. citizens who are residents of Massachusetts	**$200**
Participants in the New England Board of Higher Education Regional Student Programs	**$200**
All others	**$600**
Residence halls, per year	**$500**
Student activity and insurance fee	**$ 60**
ROTC deposit	**$ 25**
Books, supplies, and related miscellaneous expenses (approximate)	**$100**
Meal fee per year	**$390 or $409**

THE BOARD OF TRUSTEES RESERVES THE RIGHT TO CHANGE ANY OR ALL FEES WITHOUT PRIOR NOTICE.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

Fundamental to the principle of independent learning and professional growth are the requirements of honesty and integrity in the performance of academic assignments, both in the classroom and outside, and in the conduct of personal life. Accordingly, the Institute expects of its students the highest standards of intellectual integrity and thus the attempt of any student to present as his own any work which he has not performed or to pass any examinations by improper means is regarded as a most serious offense and renders the offender liable to immediate expulsion. The aiding and abetting of a student in any dishonesty is also considered a grave breach of conduct.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Full-Time Student

A full-time student is normally considered to be carrying the credit-hour load called for by the curriculum in which he is enrolled. However, since students are sometimes out of phase with the specified curriculum, for purposes of classification an undergraduate student may be classified as full-time if his approved program consists of at least 12 credit hours.

Attendance

An excused absence system is applicable. For regulations consult the KEY (Student Handbook).

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

.....A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester. Refer to THE KEY (Student Handbook) for method of calculation.

Any changes in courses or curricula must be accompanied by an academic petition.

Incomplete Grades

The grade of I for undergraduate students shall only be reported:

When a portion of the assigned or required class work or the final examination has not been completed because of necessary absence of the student due to serious illness or extreme personal or other circumstance beyond the student's control. If the student's record is such that he would fail the course regardless of the result of the missing work, he is to be given an F.

In order to qualify for an I, the student must obtain an Academic Petition form from the instructor. Such a form would not be issued if the quality of the work to date did not justify it. This form must be approved by the Dean of Students with copies returned to the instructor and filed with the Registrar.

A student can obtain credit for an I only by finishing the work of the course within two weeks from the end of the semester. The grade of I is converted to F if the course requirements have not been satisfied by this time. Exceptions to the two-week deadline may be requested on the Academic Petition and approved by the Dean of Students in cases of protracted illness or critical personal problems or for academic reasons at the request of the instructor. The initiative for removal of the I rests with the student, but faculty members giving an I must be responsible for making suitable arrangements for its removal.

An I on a final grade report is calculated as an F in arriving at a temporary rating. When the I is later converted to a grade, the permanent record is changed and the student notified.

Academic Symbols "W" and "X"

"W" and "X" are used to indicate that a student did not complete subjects and that no academic grades were given. "W" indicates that a student withdrew from the Institute for approved reasons and it would appear for all subjects he was taking at the time of withdrawal. "X" indicates that a student dropped a subject for approved non-academic reasons after the time specified in the academic calendar as the last date to add or drop subjects without approval. No "X" or "W" symbol will

be issued during the last three weeks of classes of any given semester.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

PROBATION AND DISMISSAL — ACADEMIC

Probation

A student is automatically placed on probation under the following conditions:

a. When the student's semester rating is less than 1.35

B. When the cumulative rating of a student not on probation is less than the appropriate value

Freshman Year-end	1.40
Sophomore Mid-year	1.45
Sophomore Year-end	1.50
Junior Mid-year	1.55
Junior Year-end	1.60
Senior Mid-year	1.65

The probationary period covers the entire regular semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the institute in any public function or extracurricular activity and may not hold or run for any class or other offices during the term of probation and is allowed no unexcused absences from classes.

Dismissal

A student is automatically dropped from the Institute for at least one semester under the following conditions:

A. When the student's semester rating is below 0.70 except first Semester freshman year.

B. When the student's semester rating is less than 1.35 for two consecutive semesters

C. When the student, while on academic probation, fails to achieve the cumulative rating required, in the foregoing statement on Probation.

Upon request of a student who has been notified of impending academic dismissal from the Institute by the above conditions, the Dean of Students, in the case of a freshman, and the appropriate Department Head, in the case of an upperclassman, will grant the student a hearing to review that student's case to ascertain if extenuating circumstances exist which would justify further consideration.

A student dropped from the Institute should see Readmission Policies. (p. 36)

PROBATION AND DISMISSAL — DISCIPLINARY

A student is placed on disciplinary probation by the Dean of Students when in his opinion a student has violated a basic rule of conduct or an established rule of the Institute. The probationary period covers the entire semester in which the violation took place. The length of time of the censure can be a longer period of time.

A student who violates the basic tenet of disciplinary probation may be dismissed from the Institute.

If the original violation is of a serious nature, the Dean of Students may dismiss the student without benefit of a probationary period. However, the Dean's decision is subject to appeal by the student.

Any student on disciplinary probation may not represent the Institute in any public function or any other extra-curricular activity and may not hold or run for any class office or other office during his term of probation, nor is he allowed to cut any classes or laboratory sessions.

WITHDRAWAL FROM THE INSTITUTE

Students wishing to withdraw from the Institute at any time must secure and have completed a Withdrawal Clearance Form from the Office of the Dean of Students. Students withdrawing from the Institute **prior** to the end of the semester shall receive all "F's", except for reasons of medical withdrawal, involuntary call to active duty, and/or other extenuating circumstances approved by the Dean of Students.

LEAVE OF ABSENCE: FOR STUDENTS IN GOOD STANDING

Students in good standing who find it necessary to withdraw at the end of any semester because of military service, health, financial reasons, or personal problems, may be granted a leave of absence from the Institute by the Dean of Students. The student must complete a Withdrawal Clearance Form obtained from the Dean of Students office. Readmission will be automatic for a period of up to two years and would require only the filing of a Readmission Application.

READMISSION POLICIES

Requests for readmission will be handled by the Dean of Students Office. All correspondence should be sent to this office. The procedure to follow and all information needed is listed below.

1. Students desiring consideration for readmission must submit pages 1 and 2 of our application.
2. Student Data Sheet must be completed in its entirety.

3. A Check in the amount of $10.00 made out to Lowell Technological Institute must be included.

4. A letter giving original date of entrance to this college, date and **reason** for withdrawal and a brief resume of what you have done since you left L. T. I. must accompany the application. (N.B. If withdrawal was for medical reasons, you must include a doctor's certificate certifying ability to attend school again).

5. Students desiring transfer credit should supply an official transcript sent to us by the colleges attended. Only those courses graded in "C" range or better will be considered. Those students who withdrew because of scholastic difficulty must have had prior approval on the required credit form obtained at the Registrar's office in order to have their courses considered for credit.

6. Completed applications for September readmission must be received no later than May 15.

Completed applications for February readmission must be received no later than January 1.

7. When the Dean of Students deems it necessary a student will be asked to make himself available for an interview.

8. Only when all of these items have been received in the Dean of Students office will the application be considered for readmission.

Final decision will be made by the Dean of Students and/or the Department Head for upperclassmen as to whether or not readmission would serve the best interests of the student and the Institute. Approval of readmission is not automatic and all decisions will be final.

9. A letter will be sent notifying you of the decision from the Dean of Students Office. No notification will be given by telephone or in person.

RULES OF CONDUCT

The Board of Trustees recognizes the dual obligation of the Institute to insure the orderly pursuit of its proper functions at all times while preserving the rights of individuals and groups to freedoms guaranteed by our national and state constitutions and normally prevailing in the academic community. The Board of Trustees recognizes and defends the right to open discussion, the right to hold and articulate one's own beliefs and convictions, the right of peaceful assembly, the right to petition, the right to distribute handbills and circulars, the right to a fair hearing, and such other rights as are inseparable facets of the concept of academic freedom and are indispensable for the transmission of knowledge, the pursuit of truth, the development of

students, and the general well-being of society. The basic distinction to be made is that between those activities which are consistent with our obligation as an academic institution dedicated to free inquiry and free expression and to safeguarding the freedom to teach and the freedom to learn and those activities which are inconsistent with this obligation. It follows that there is a responsibility for the Institute to draw clear distinctions between conduct on the part of members of the Institute community and visitors to the Institute which is acceptable and that which is not. The rules set forth below are effective in accordance with the existing laws of the Commonwealth and the nation.

The following activities are among those which are considered unacceptable because of their adverse effect on the preservation of freedom or on the orderly pursuit of Institutional work:

1. Obstruction or disruption of teaching, research, administration, or other Institute activities, including the Institute's public service functions or of other authorized activities, on Institute owned or controlled property;

2. Obstruction of the free flow of traffic, both pedestrian and vehicular, on Institute owned or controlled property;

3. Physical abuse or detention of any person on Institute owned or controlled property or at any Institute sponsored or supervised functions, or conduct which endangers the health or safety of any person;

4. Theft or damage to property of the Institute or of property of a member of the Institute community or the property of a visitor to the Institute;

5. Unauthorized entry to or use of Institute facilities, including both buildings and grounds;

6. Violation of Institute established policies or regulations, including regulations in the Catalogue, the "Key" and other publications pertaining to student organizations, student, faculty, administrative staff, non-academic employees and visitors conduct, the use of Institute facilities, or procedures concerning the time, place and manner of public expression;

7. Violation of rules governing residence in Institute owned or controlled property;

8. Use, possession, or distribution of narcotic or illegal drugs on Institute owned or controlled property, except as expressly permitted by law;

9. Failure to comply with directions of Institute police and any other law enforcement officers acting in performance of their duties and to identify one's self to these officers when requested to do so;

10. Illegal or unauthorized possession or use of firearms, explosives, dangerous chemicals or other weapons on Institute owned or controlled property;

11. Failure to comply with the directions of Institute officials acting in the performance of their duties;

12. Disorderly conduct, breach of the peace, and aiding, abetting or procuring another to breach the peace on Institute owned, or controlled property or at Institute sponsored or supervised functions.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors — graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors — graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors — graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Defense Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates, through the College Scholarship Service, Princeton, New Jersey.

Students may obtain applications and information regarding these programs at the Financial Aid Office, O 112.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergradaute program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Financial Aid Officer before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Alumni Association Scholarships

The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

AFROTC College Scholarship Program

High school students desiring information on the 4-year AFROTC College Scholarship Program should see their school guidance counsellors or write directly to AFROTC (OTTA), Maxwell AFB, Alabama 36112 for further information. Normal deadline application is 15 November each year.

Scholarships are provided on a competitive basis to a limited number of male and female cadets entering Aerospace Studies 200-300 in the Air Force ROTC four year program. The scholarship covers full tuition costs, books, laboratory expenses and incidental fees. A scholarship earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable standards. Cadets also receive $50. per month subsistence allowance.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, and Littleton, Mass.; West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

Outside Scholarship Assistance:

The Afro-American Society at L.T.I. has compiled a list of Private, Public, and Federal Scholarships, Funds, Fellowships, and Loan Programs that are available to disadvantaged persons.

The Financial Aid Office has copies of this list which will be sent upon request. Correspondence should be addressed to the Director of Financial Aid, Lowell Technological Institute, Lowell, Massachusetts 01854.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Corporation Scholarship

The Allied Chemical Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

Boston Paper Trade Association Awards

One award, of $300, is open to upperclassmen enrolled in the Paper Engineering Department. Awards are based on character, proven interest in the Paper Industry and academic performance.

Roland E. Derby, Sr. Memorial Scholarship

This Scholarship established in memory of Roland E. Derby, Sr. provides a $500 scholarship to a sophomore student who is a candidate for a degree in Chemistry, Textile Chemistry, or Chemical Engineering. Selection by the Scholarship Committee shall be based on scholastic achievements, but due consideration shall also be given to financial need. The scholarship shall be renewable for the Junior and Senior year provided the recipient maintains a satisfactory academic record.

Foster Grant Scholarships

The Foster Grant Company, Inc., of Leominster, Mass., makes available on a one-year basis two scholarships to deserving students in Plastic Technology who are residents of Massachusetts. Preference is given to sophomores living in the Leominster area; however, if there are no applicants from that area, other candidates may be chosen. Scholarship, personality, and overall student contribution to extracurricular activities are the general criteria used in selecting the recipients.

General Electric Scholarship

The General Electric Company has made available on a one-year basis a scholarship for an upperclassman majoring in Plastic Technology.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

Nylon Engineering, Inc. Scholarship

This scholarship in the amount of $250.00 is awarded annually by the Nylon Engineering, Inc. to an upperclassman majoring in Plastics.

Mobay Scholarship

The Mobay Chemical Company of Pittsburgh, Pennsylvania has made available on a one-year basis a scholarship to be awarded to a deserving upperclassman majoring in Plastics Technology.

Paper Engineering Department Scholarships

Ten or more scholarships with annual stipends of $500 are available to upperclassmen and selected graduate students in Paper Engineering who fulfill the scholarship requirements of a minimum of 2.0 cumulative rating. These scholarships are normally maintained from year to year provided the student maintains his academic rating.

Contributors to the Scholarship Fund include the following:

Bertrand Hopper Memorial Fund
Byron Weston-Crane Company
Carter Rice Storrs and Bement, Inc.
Weyerhaeuser Company
Erving Paper Mills
Fraser Paper, Ltd.
Ludlow Corporation
Nashua Corporation
Chas. T. Main Co.
Deerfield Glassine Co.
Gulf States Paper Company
Dennison Foundation
Uniroyal, Inc.
Diamond Automation
Newton Falls Paper Mill, Inc.
Albany International
The Dexter Corporation
Draper Brothers Company
Cheney Bigelow Wire Works, Inc.

Sonoco Products Company
Merck Chemical Co.
Arthur L. Goeschel
E. F. Houghton and Co.

Rohm and Hass Corporation Scholarship

The Rohm and Hass Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

S.M.E. Awards

Merrimack Valley Chapter 113, Society of Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The S.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

William C. Smith Trust Fund Scholarship

This fund has been established to provide scholarship assistance to students majoring in Chemistry.

Society of Plastics Engineers Scholarships

Two scholarships are granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to upperclassmen majoring in Plastics Technology.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry or Textile Chemistry in the amounts of $225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school, interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

Available to Undergraduate and Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3% beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry Course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

SME Award. The Merrimack Valley Chapter, Society of Manufacturing Engineers awards $100 to a member of the Student Chapter of the SME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

The Wall Street Journal Student Achievement Award. This award recognizes the senior in Business Administration or Industrial Management who has achieved the best combination of academ-

ic and extracurricular excellence. The award consists of an engraved paperweight, a year's subscription to the Wall Street Journal, and a plate on the permanent plaque established for the award winners.

OTHER ASSISTANCE FOR MASSACHUSETTS Residents Only

Board of Educational Assistance Scholarships

General Scholarships provide for tuition payments and are available primarily to freshmen and are based solely on financial need. Honor Scholarships provide for tuition and are based solely on academic ability (SAT scores). Scholarships are also available to the children of deceased uniformed members of a paid fire department or permanent members of a police department, the force of the MDC, or the Capital Police. Such death must have been the result of injuries received in the line of duty. For full information contact:

Board of Higher Education
Scholarship Office
182 Tremont Street
Boston, Mass. 02111

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1,000 a year for undergraduate school, or $1,500 a year for graduate school. There is no interest charge on such loans while the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 7% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Masachusetts 02116
Telephone 426-9434

PLACEMENT

Industrial Training Program

The Placement Office maintains two basic functions. One is to counsel the senior planning to take recruiting interviews; the other is arranging the dates of interviews for the representatives of the recruiting companies and agencies.

In the counselling process the Placement Officer reviews the student's transcript with him, discussing his points of strength and weakness. The elements of the recruiting procedure are explained so that he may be properly prepared for the ensuing interviews.

Approximately one hundred and eighty companies and government agencies recruit on the LTI campus. The companies represent a cross-section of industry in the country ranging from the so-called giants down to those of relatively small size. Geographically, they are located in the Northeast, the Southeast and the Mid-West with a few from the Far West. Thus, the seniors get fairly broad exposure to business opportunities.

SUMMER SCHOOL

All Summer Session programs are conducted on a self-supporting basis with no financial assistance from the Commonwealth of Massachusetts.

The programs are designed to serve the following areas of interest:

1. UNDERGRADUATE CREDIT PROGRAM

Two six-week sessions, paralleling the two 15-week academic year semesters, stress fundamental credit offerings in mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

These sessions provide an opportunity for deficiency clearance and for advanced standing.

2. PRECOLLEGE REFRESHER PROGRAM

This five-week, noncredit program caters to prospective L.T.I. freshmen who require additional background to fulfill minimum entrance requirements.

Students must first apply for fall admission; the Dean of Admissions designates the subject or subjects required for coverage of minor deficiencies in the high school background. Subject areas include: English, mathematics, chemistry, and physics for engineering applicants; English, mathematical analysis, and general science for business administration majors.

3. PROFESSIONAL ADVANCEMENT PROGRAM

Industry-sponsored noncredit courses, similar in scope to the **continuing education** courses conducted during the academic year, may be arranged during the Summer Session. Additionally, the SUMMER EVENING PROGRAM and courses conducted through special grants are offered under this heading.

Note: Summer evening offerings are conducted through the DIVISION OF EVENING STUDIES in a single, six-week session. Credits apply **only** to Evening Division Programs.

4. GRADUATE CREDIT PROGRAM

Selected graduate credit subjects are offered for students who have been admitted to advanced study by the L.T.I. GRADUATE SCHOOL. The Dean of the Graduate School must approve all offerings and registration is carried out through the Graduate School Office.

The L.T.I. Summer Session is a member in good standing of the National Association of Summer Sessions (NASS).

For further information or a Summer Session Bulletin, write to the Director of Summer School.

THE MARTIN LUTHER KING, JR. EDUCATIONAL OPPORTUNITY PROGRAM

A program proposed by the Lowell Technological Institute Afro-American Society has been added to the Institute structure. This program is named in honor of the late Dr. Martin Luther King, Jr. the Nobel Laureate and champion of disadvantaged people of all races.

The King Educational Opportunity Program has been designed to provide an opportunity for higher education at LTI to individuals who have been hindered in their academic achievements due to adverse financial and environmental factors. The first program year will start in June of 1972. Thirty Massachusetts high school graduates will be enrolled in the program each year. They attend a summer session for program orientation, academic needs evaluation, counseling, and required remedial studies.

The normal course load, remedial studies, and tutoring assistance of students enrolled in the program will be adjusted to the needs of the individual. It is expected that the average student will complete the normal four year curriculum in five years. Students accepted into the program will receive full financial support for the five year period.

For further information, write to the Acting Director, Dr. Jesse Y. Harris.

THE GRADUATE SCHOOL

General Information

The Lowell Technological Institute Graduate School, which was founded in 1935, offers advanced studies, including professional training and research leading to graduate degrees in many fields of engineering and in certain areas of pure and applied science. In addition to the day classes intended primarily for full-time graduate students, the Graduate School offers some evening courses through the Division of Evening Studies mainly for the convenience of part-time students primarily interested in advanced professional training. The courses offered in the evening are equivalent in every respect to those offered to the day students for they are simply evening sections of courses offered during the day. There are currently 100 graduate students enrolled in degree programs for advanced professional training in these Evening Division courses out of a total Graduate School enrollment of 445 students. These part-time students are primarily from the large industrial companies nearby the Institute located principally in the Merrimack Valley. Professional graduate programs, which would include the graduate programs in Plas-

tics, Paper, Textiles, Nuclear Engineering and Management Science are in wide demand by industry in New England and in Massachusetts in particular. These programs serve as excellent supplements to the standard curricula in the basic engineering and science areas which are listed below. In June of 1971, there were 43 Master of Science degrees and 3 Doctor of Philosophy degrees granted through the Graduate School at LTI.

Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree or equivalent in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality. It is the policy of Lowell Technological Institute to accept all students without regard to race, color, or national origin.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed in duplicate and returned to the Dean of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by recommendations from at least three persons qualified to judge the ability of the applicant to carry on graduate work and research. The recommendations should be sent directly from these persons to the Graduate School.

Two copies of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B— and if these subjects were not used in earning another degree at the same level. All applicants must submit one additional copy of a transcript which includes the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within one semester after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning two completed application forms and having transcripts and recommendations sent, the applicant must take the Graduate Record Aptitude Test and the appropriate Advanced Test and have the results sent to the Dean of the Graduate School. Information regarding the Graduate Record Examinations may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N.J. 08540 or Box 27896, Los Angeles, California 90027, whichever is nearest to the applicant.

Academic Expenses

Tuition (per semester)	
U. S. citizens who are residents of Massachusetts and	$10 per credit hour up to $100 maximum
Participants in the New England Board of Higher Education Regional Student Program	$10 per credit hour up to $100 maximum
All others including foreign students	$30 per credit hour up to $300 maximum
Graduate Student Activity Fee (per year)	$32.00
Commencement Fee	$25.00
Thesis Binding Fee (per copy)	$5.00
Microfilm Fee (M.S.)	$15.00
Microfilm Fee (Ph.D.)	$25.00

DEGREES OFFERED

Master of Science Degrees

Applied Biology
Applied Mathematics
Chemical Engineering
Chemistry
Computer Engineering
Electrical Engineering
Environmental Studies
Mathematics
Mechanical Engineering
Nuclear Engineering
Paper Engineering
Physics
Plastics
Polymer Science
Radiological Sciences
Systems Engineering
Textile Engineering

Doctor of Philosophy Degrees

Chemistry
- a. Inorganic
- b. Organic
- c. Physical

Chemistry — Polymer Science Option

Physics (Experimental and Theoretical)
- a. Nuclear
- b. Solid State
- c. Particles & Fields
- d. Underwater Acoustics

Professional and Other Degrees

Master of Management Science (M.M.S.)

For further information concerning the graduate programs, please consult the Graduate School Catalog.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Office, the Research Foundation, the Pinanski Nuclear Center, WLTI, the Research Foundation, the Alumni Memorial Library and the Summer School, the college provides such services to industry and the community as the following:

Industrial seminars and conferences;

Technorama, science fair for area high schools;

Consultive opportunities with administration and faculty;

Special radio and television programs;

Collaboration with the Agency for International Development in its foreign aid programs;

Participation with local and state agencies in the solving of ecological problems.

For information concerning these programs, address the Department of Public Relations at the Institute.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers Undergraduate Programs leading to Associate and Baccalaureate Degrees; and part-time Graduate Programs offering a Master's Degree. Satellite programs are provided for area industries. The majority of the degree programs are in the fields of science, engineering technology and business administration. An increasing number of students who have completed an Associated Degree Program on a full-time basis and have become full-time employees are continuing their education on a part-time evening basis in the Baccalaureate Programs.

Additionally, individual subjects in mathematics, science, technology, engineering, business, and general studies may be taken as a special student.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers In-Service Training Programs limited to employees of the Commonwealth and cities and towns within the Commonwealth. These undergraduate programs lead to Associate and B.S. degrees in Civil Engineering Technology, Associate in Business Administration (in either Accounting or Data Processing), and Bachelor

in Business Administration. The Associate and B.S. Degree programs in Civil Engineering Technology are accredited by the Engineers' Council for Professional Development.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION

Established in 1950 by the Board of Trustees of the Lowell Technological Institute, the Research Foundation is a not-for-profit organization that does research in a wide variety of fields. The operation is fully self-supporting from income derived from its industrial and government sponsors.

The Research Foundation is housed in a one-story modern building across the Merrimack River from the Institute's main campus. Initially its prime purpose was to answer the needs of the Lowell Technological Institute for facilities and staff to perform basic and applied research in textiles and related subjects. As the Research Foundation expanded, a diverse and growing program of research and development activities increased extensively, and projects have moved into the fields of chemistry, leather, paper, plastics, electronics, physics, oceanography, nuclear engineering and environmental pollution, in addition to management and economic development assignments.

The Research Foundation is presently composed of five major divisions: Electronics and Physics, Ionospheric Science, Environmental Pollution, Economic Development, as well as a Testing Division.

The Electronics and Physics Division is primarily interested in electronics, electro-mechanical design and development, applied electronics and physics, electro-magnetic interference reduction, power supply technology, and metrology services.

The Ionospheric Science Division is concerned with instrumentation, measurement, data analysis and theoretical studies of the ionosphere and its effect on communications.

The Environmental Pollution Division's areas of interest are air and water pollution sampling and analyses, waste treatability and reuse studies, and plant project design consulting.

The Economic Development Division works in the areas of economic studies, marketing, general management, and manufacturing services.

The Testing Division is mainly concerned with the testing and evaluation of a wide variety of materials submitted by industrial and Government sponsors.

Students are encouraged to visit the Research Foundation.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts 01854.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, student loan program, publishes the official alumni newsletter, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four executive officers elected by the student body and the officers of each class. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Afro-American Society

This organization assists and organizes whatever separate group and/or function that will allow those individuals dedicated to the benevolent welfare of black people to invest their energies.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Amateur Radio Club

This organization is enjoined to promote the fraternity of Amateur Radio at Lowell Tech and specifically to promote the fellowship of amateur radio through on-the-air activities. To aid interested individuals in obtaining their amateur radio license as well as helping current license holders advance their grades.

Amateur Rocketry Organization

The purpose of this organization is to conduct experiments, research projects and other educational activities designed to increase the knowledge of its membership in the science of modern rocketry and in the technologies related to it.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Archery Club

The purpose of the Archery Club is to promote sportsmanship and accuracy in archery among the student body. Membership is open to all students and faculty at the Institute.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier current radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition has extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multipurpose room and radio studios.

WLTI was originally organized as the Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10Kw FM transmitter. Work is now underway on the renovation of this equipment and the licensing of the station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Bridge Club

The duplicate Bridge Club is open to all students and faculty who are interested in either learning or playing bridge. The club meets every Wednesday in informal session in Eames Lounge and refreshments follow each meeting.

Cadet Advisory Council

The purpose of Cadet Advisory Council is to handle grievances and recommendations concerning actions and policies o the Cadet Corps.

Cheerleaders

The Cheerleaders encourage and promote the enthusiasm of the Student Body as well as that of the team members at L.T.I. basketball games.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Student Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interest and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen. They are also responsible for publishing the student handbook, THE KEY.

Cricket Club

The purpose of this club is to promote good sportsmanship among the student body by encouraging active participation in this challenging sport.

Current Issues and Affairs Committee

Membership in the society is open to all members of the academic community at Lowell Technological Institute. The objectives of the committee are (1) to provide a forum for the discussion of current events in the educational, political, social and economic fields, and (2) to establish a vehicle for the implementation of those measures believed essential in the foregoing fields by the majority of the members; all implementation procedures conforming to law and rules and regulations of the Institute.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization

is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fencing Club

The Fencing Club makes available to our student body instruction in the fine art of fencing.

Football Club

The purpose of this club is to act as a vehicle to promote the spirit of the academic community by offering the student body organized football.

Fraternities

There are fraternities — Delta Kappa Phi, Kappa Sigma, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, Sigma Phi Omicron, and Tau Kappa Epsilon — all have their own fraternity houses. All provide social life off campus and four are national fraternity affiliates. The Inter-fraternity Council fosters the common interests of the seven and sponsors interfraternity social and athletic events.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

Interdormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Karate Club

Instruction in Karate is made available to members of this organization.

THE KEY

The publication, THE KEY, is the student handbook which contains the rules and regulations at the Institute. While not an official document, it is a true guideline in orienting students in their transition into college life.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units. Pershing Rifles maintains a residence which houses several members and is the center of social activity for the organization.

Photography Club

The purpose of this organization is to provide a time, place, and opportunity for members to acquire and discuss photographic techniques, to perform photographic services for other campus organizations, and to exhibit and promote general interest in photographic art.

Pickout

The Pickout is the college yearbook. Its student staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

American Association for Textile Technology, Student Chapter

American Chemical Society, Student Chapter

American Institute of Chemical Engineers, Student Chapter

American Society of Civil Engineers, Student Chapter

American Meteorological Society, Student Chapter

American Nuclear Society, Student Chapter

American Society of Mechanical Engineers, Student Chapter

Biology Club

Industrial Management Society

Institute of Electrical and Electronics Engineers, Student Chapter

MALTI (Mathematics Association of LTI)

Sigma Kappa Psi

Society for Advancement of Management, Student Chapter

Society for Manufacturing Engineers

Society of Physics Students

Society of Plastics Engineers, Student Chapter

TAPPI (Student Chapter, Tech. Association of Pulp & Paper Industry)

Religious Groups

United Campus Ministry

Rabbi Benjamin Tumim, Chaplain; Hillel Counsellorship

Reverend K. Gordon White, Chaplain, Iona Fellowship

Reverend Paul T. Walsh, Chaplain, Newman Community

Reverend Joseph D. Flynn, Chaplain, Newman Community

Reverend John P. Sarantos, Chaplain, Phanar Club

THE UNITED CAMPUS MINISTRY OF LOWELL is a federation of students, spiritual and faculty advisors of the various religious organizations of Lowell Technological Institute, Lowell State College and Lowell General Hospital School of Nursing, which sponsors ecumenical programs throughout the academic year. For information, contact Rev. Paul T. Walsh, the Chairman-chaplain at the NEWMAN CENTER.

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of

Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Community

Through the combined efforts of the spiritual advisors and many local friends, the Newman Community now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI, Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National

Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Service Club

The co-eds at the Institute have formed this organization to be of service to the Institute, and in particular, the athletic department. Some projects undertaken by members are greeting visiting teams, assisting visiting coaches in any way possible, score keeping, time keeping, working with judges. The girls also serve as usherettes, selling programs, etc.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Sororities

BETA TAU Sorority was recently established on campus to promote good fellowship and high scholarship. As a service sorority, BETA TAU participates in many campus and community activities.

PHI SIGMA RHO, established in 1937, is the oldest sorority on campus. Its members enjoys the bonds of sisterhood as well as take an active part in social, civic, and recreational activities.

The activities of PHI SIGMA RHO and BETA TAU are governed by the Interfraternity Sorority Council.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The weekly publication offers excellent journalistic and business experience to those who work on its staff.

Colonel Charles L. Vacanti Squadron of the Arnold Air Society

The Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs, charitable works, and aerospace exhibits during the year. Community services include visits to the veterans hospitals, the annual food drive for the needy and the annual blood drive. The Squadron sponsors the annual Military Ball, which is a social highlight of the year.

Varsity Club

Membership is open to anyone who has been a member of a team and participated in the intercollegiate sports program. This organization shall strive to help the student athlete academically. It will be of service in the promotion and development of the intercollegiate athletic program, as well as foster a lasting friendship among the men and women participating in athletics at Lowell Technological Institute.

Veterans Club

The objectives of this club shall be to present programs of interest and importance to the membership of the club, to service all veterans whether or not they are members of the organization, to assist members in finding part-time and summer employment, and to actively participate and become interested in academic and non-academic areas of concern within the Institute.

Veterans

G. I. Bill

Veterans attending LTI may apply for financial assistance under the GI Bill. Application should be made to your local VA Office for details. Proof of your student status should be obtained by presenting your acceptance from the Admissions Office and,

upon registration, the Registrar's Office should be requested to notify the VA as to your student status.

Certificate of Eligibility

Veterans whose service is credited to Massachusetts are entitled to free tuition for four years at Massachusetts colleges. In order to obtain the Certificate you must present your discharge paper (DD 214) to the Adjutant-General's Office in the State House in Boston. Upon receiving verification, you should bring it to the Massachusetts Department of Education at 182 Tremont Street, Boston and request the Certificate. A request should then be filed with the Office of the Registrar during registration to inform the Department of Education as to your status and also with the Bursar's Office to the effect that you will present the Certificate to them when you receive it.

THE THREE CATEGORIES BELOW CLASSIFY OUR STUDENTS AS VETERANS IN TERMS OF THE PHYSICAL EDUCATION REQUIREMENT AT THE INSTITUTE:

1. National guard — six-year period — discharged and military obligation completed.
2. National guard — six-months active duty completed and serving five and one-half years of reserve training.
3. Student who fulfills military obligation on active duty in the armed services.

UNDERGRADUATE PROGRAMS

Fifteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Biological Sciences	Mechanical Engineering
Business Administration	Meteorology
Chemical Engineering	Nuclear Engineering
Chemistry	Physics
Civil Engineering	Plastics Engineering
Electrical Engineering	Radiological Health Physics
Industrial Management	Mathematics
Industrial Technology	

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students.

A special curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering is open as an In-Service Training Program for employees of the Commonwealth of Massachusetts and its political subdivisions. Regulations for entrance into the program and subjects required prior to attending day classes as in-residence students are shown in the Catalogue of the Division of Evening Studies of the Lowell Technological Institute. A portion of the curriculum is given during the day and is contained in this catalogue under Civil Engineering Technology.

Other baccalaureate degree programs in fields of Technology and Business are given in the Division of Evening Studies and are described in the Catalogue of the Division of Evening Studies.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and average number of hours in laboratory; after the parentheses, number indicates credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits.

Some undergraduate subjects may be taken for graduate credit. Consult the Graduate School catalogue for details.

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospaces Studies	IT	Industrial Technology
BI	Biological Sciences	LL	Languages and Literature
BA	Business Administration	MA	Mathematics
CN	Chemical Engineering	ME	Mechanical Engineering
CH	Chemistry	MY	Meteorology
CE	Civil Engineering	NU	Nuclear Engineering
DP	Data Processing	PH	Physics
EC	Economics	PL	Plastics
EE	Electrical Engineering	RS	Radiological Sciences
IM	Industrial Management	SS	Social Sciences

SUBJECT NUMBERS

The numbers following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are normally for graduate students but may be taken by undergraduates in certain cases with special permission.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

PREREQUISITES

Prerequisites and restrictions are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

CLASS AND CREDIT HOURS

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

THE ELECTIVE SYSTEM

In all curricula an opportunity is given the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

Prior to the registration period for each semester, a list of the General Electives to be offered is made available to faculty and students. **To ensure fulfillment of degree requirements and accreditation standards, all General Elective choices must be approved by the Department Head or the Advisor in the curriculum in which the student is a degree candidate.**

Subjects taken in the United States Air Force ROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. However, subjects taken in the junior and senior years in the ROTC program may be elected to fulfill degree requirements up to a maximum of 6 credits in all curricula **unless otherwise specified.** In most curricula this can be done only in the senior year.

EC 302	Labor Economics	(3-0)3
EC 303	Microeconomic Theory	(3-0)3
EC 304	Macroeconomic Theory	(3-0)3
EC 305	Regional Economics	(3-0)3
EC 306	Urban Economics	(3-0)3
EC 307	Economic Analysis of Urban Problems	(3-0)3
EC 402	Government and Business	(3-0)3
EC 403	International Trade Theory	(3-0)3
EC 404	Comparative Economic Systems	(3-0)3
EC 405	Marxism and the Soviet Economy	(3-0)3
EC 406	Welfare Economics	(3-0)3
EC 407	Econometrics	(3-0)3
EC 408	History of Economic Thought	(3-0)3
EC 409	Growth Theory	(3-0)3
EC 410	Economic Development of Less Developed Countries	(3-0)3
EC 411	Public Finance	(3-0)3
EC 412	Managerial Economics	(3-0)3
EC 414	Engineering Economy	(3-0)3
LL 207	Oral Business Communication	(3-0)3
LL 209	Technical and Scientific Communication	(3-0)3

LL 213	Introduction to English Literature: to 1798		(3-0)3
LL 214	Introduction to American Literature: from 1865		(3-0)3
LL 215	Introduction to American Literature: to 1865		(3-0)3
LL 216	Introduction to English Literature: from 1798		(3-0)3
LL 218	Afro-American Literature		(3-0)3
LL 219	The Film in Communication		(3-0)3
LL 221	Educational Broadcasting Philosophy Laboratory		(1-6)3
LL 222	Educational Broadcasting Philosophy		(2-2)3
LL 224	Literary Criticism for the Technology Major		(3-0)3
LL 233	Comparative Literature		(3-0)3
LL 234	Shakespeare		(3-0)3
LL 235	English Drama After Shakespeare		(3-0)3
LL 238	Science and Literature		(3-0)3
LL 259-260	Elementary German	(3-0)	(3-0)6
LL 261-262	Elementary Technical German	(3-0)	(3-0)6
LL 263-264	Elementary French	(3-0)	(3-0)6
LL 265-266	Elementary Russian	(3-0)	(3-0)6
LL 267-268	Elementary Spanish	(3-0)	(3-0)6
LL 269	Literature of the Beats		(3-0)3
LL 309	Woman in Modern Fiction		(3-0)3
LL 311	Creative Writing and Advanced Composition		(3-0)3
LL 313	Introduction to Continental Literature		(3-0)3
LL 314	Continental Literature Since the Renaissance		(3-0)3
LL 315	Myth and Symbol in Literature		(3-0)3
LL 316	The English Bible as Literature		(3-0)3
LL 318	The Evolution of the Existential Hero		(3-0)3
LL 319-320	The Image of Man in Western Thought	(3-0)	(3-0)6
LL 333	Problems of Philosophy		(3-0)3
LL 335	The Southern Renaissance in American Literature		(3-0)3
LL 341	Satire		(3-0)3
LL 342	Utopian Literature		(3-0)3
LL 344	Modern American Poetry		(3-0)3
LL 345	Modern Irish Literature		(3-0)3
LL 363-364	Intermediate French	(3-0)	(3-0)6

LL 365-366	Intermediate Literary and Conversational Russian	(3-0)	(3-0)6
LL 367-368	Intermediate German	(3-0)	(3-0)6
LL 369-370	Intermediate Spanish	(3-0)	(3-0)6
LL 431	Philosophy of Science		(3-0)3
LL 435	English Literature of the Eighteenth Century		(3-0)3
LL 436	English Romantic Poets		(3-0)3
LL 443	Science Fiction		(3-0)3
LL 444	Popular Culture		(3-0)3
LL 467	Seminar in German Masterpieces		(3-0)3
LL 471	The Modern American Novel		(3-0)3
LL 472	The Modern British Novel		(3-0)3
LL 473	World Drama		(3-0)3
LL 474	Modern Drama		(3-0)3
LL 476	Nineteenth-Century British Novel		(3-0)3
LL 481	Classical Literature		(3-0)3
LL 482	The Short Story		(3-0)3
LL 495-496	Reading and Research		6
LL 961	British Literature		(3-0)3
LL 962	American Literature		(3-0)3
SS 223	The United States: 1865-1917		(3-0)3
SS 224	The United States: 1918-1945		(3-0)3
SS 225	Europe: 1789-1914		(3-0)3
SS 226	Europe: 1914 to the Present		(3-0)3
SS 232	Social and Economic Change in Europe: 1750 to the Present		(3-0)3
SS 235	England: Roman Times to the Restoration		(3-0)3
SS 236	England: The Restoration to the Present		(3-0)3
SS 238	Revolutions in European History		(3-0)3
SS 240	European Urban History		(3-0)3
SS 242	European Imperialism		(3-0)3
SS 301	Government of the United States		(3-0)3
SS 303	Psychology		(3-0)3
SS 305	Sociology		(3-0)3
SS 307	Seminar in Small Group Analysis		(3-0)3
SS 308	Psychology of Interpersonal Behavior		(3-0)3
SS 310	Contemporary Social Problems		(3-0)3
SS 315	Sociology of Deviance		(3-0)3
SS 320	Urban Sociology		(3-0)3
SS 322	Moral Problems in Technological Age		(3-0)3
SS 335	American Economic History		(3-0)3

SS 340	The United States: 1945 to the Present	(3-0)3
SS 352	Contemporary Political Theory	(3-0)3
SS 360	Government of China	(3-0)3
SS 362	Social Psychology	(3-0)3
SS 401	Afro-American History	(3-0)3
SS 404	Technology and Social Change I	(3-0)3
SS 405	Technology and Social Change II	(3-0)3
SS 406	The Technological Future: The Material Aspects	(3-0)3
SS 407	The Technological Future: The Social and Political Aspects	(3-0)3
SS 410	History of Science and Technology	(3-0)3
SS 451	History of France	(3-0)3
SS 452	Seminar in Recent American History	(3-0)3
SS 453	Seminar in Modern European History	(3-0)3
SS 454	Seminar in Political Science	(3-0)3
SS 455	Seminar in Psychology	(3-0)3
SS 456	Seminar in Sociology	(3-0)3
SS 460	Elements of Urban Affairs	(3-0)3
SS 461	Studies in Regional and Metropolitan Development	(3-0)3
SS 462	Urban Reform	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	National Security Policy	(3-0)3
SS 474	Cultural Anthropology	(3-0)3
SS 478	Russia: The Soviet Union	(3-0)3
SS 482	The United States: Urban History	(3-0)3
SS 483	The Development of Western Civilization: to 1453	(3-0)3
SS 484	The Development of Western Civilization Since 1453	(3-0)3
SS 485	Comparative World Governments	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-0)3
SS 489	Political Parties in the United States	(3-0)3
SS 497	Tutorial in the Social Sciences	(3-0)3
SS 528	Social Ecology	(3-0)3

THE FRESHMAN PROGRAM

The Freshman Program in both the Colleges of Science and Engineering has been changed from a rigorous combination of Chemistry, Physics, Mathematics and English to one which provides for individual differences and eases the transition from high school to college.

In Math and Physics, students will be assigned to sections according to their mathematical aptitudes and high school records. Physics and Chemistry will be taught in relatively small classes where more attention can be given individual students.

A new Freshman Seminar will introduce students to elementary concepts of Science and Engineering, emphasizing the natural interface these subjects have with the social sciences. Counseling will be an important function of this seminar. Responsibility for counseling students will be a part of each faculty member's teaching assignment.

A Director of Freshman Studies has been appointed to work with each course coordinator, the Dean of Students and the Dean of Admissions.

The Freshman Program

All freshmen except those enrolled in Business Administration, Industrial Management* or Industrial Technology take the following subjects:

FIRST YEAR			1st SEM.	2nd SEM.
Chem. Principles	CH121	CH122	(3-0)3	(3-0)3
Chem. Prin. Lab.	CH123	CH124	(0-2)1	(0-2)1
English I, II	LL111	LL112	(3-0)3	(3-0)3
Col. Math I, II	MA131	MA132	(4-0)4	(4-0)4
Physics	PH141	PH142	(3-1)3	(3-1)3
		or		or
		PH144		(4-1)4
Frosh Seminar	FS001		(1-0)1 P/F	
Physical Ed.	PE101	PE102	(0-2)1	(0-2)1
	TOTAL HOURS		(14-5)16	(13-5)15
				or
				(14-5)16

*Industrial Management Majors substitute EC201, Economics (3-0)3 and EC202, Economics (3-0)3 for CH 121, CH123 and CH122, CH124.

INDUSTRIAL TECHNOLOGY PROGRAM

This program has been designed to increase the variety of educational opportunities available to undergraduate students at the Institute. In particular it will provide opportunity for those students who desire an industrial career in that area located between Engineering Science and Business Administration, emphasizing the applied aspects of industrial materials, machines, processes, procedures, and human relationships.

The industrial Technology Graduate, by virtue of his knowledge of basic industrial skills, is in a position to assist operations involved in the manufacture of finished products and components, to establish and supervise production procedures, to supervise the flow of supplies and products, and in general to cope with technical and managerial production problems.

A significant feature of the Industrial Technology Curriculum is the development of a broad background for the student which, together with a reasonable amount of on-the-job-training, makes the Graduate flexible and capable of adapting to a very wide variety of industrial organizations and problems.

The curriculum is technically based, with a balanced selection of subjects including a well rounded understanding of materials and manufacturing processes, concepts of business management and human relations, communication skills, electives in humanities and social sciences, and a background of mathematics and physical sciences.

All freshmen enrolled in Industrial Technology take the following subjects:

FIRST YEAR		1st SEM.	2nd SEM.
Acct. Mgmt. I, II	BA143 BA144	(3-0)3	(3-0)3
English I, II	LL111 LL112	(3-0)3	(3-0)3
Math Anal. I, II	MA101 MA102	(3-0)3	(3-0)3
Chem. & Physics	CH129 PH149	(3-0)3	(3-0)3
or			
Physics & Chem.	PH149 CH129	(3-0)3	(3-0)3
Hum. or Soc. Sci.	Electives	(3-0)3	(3-0)3
Phy. Ed.	PE101 PE102	(0-2)1	(0-2)1
	TOTAL HOURS	(15-2)16	(15-2)16

Admission requirements for Industrial Technology are the same as for Business Administration.

COLLEGE OF ENGINEERING

COLLEGE OF ENGINEERING

The College of Engineering is organized into Departments of Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Plastics Technology. Each offers a specialized four-year program leading to a Bachelor of Science degree. For details of Engineering Graduate Programs see the Graduate Catalogue.

Broadly defined, engineering is a profession which seeks to apply scientific knowledge for the improvement of society. Because of the vastly varied needs of society and differences in individual talent and motivation, a wide spectrum of engineering education programs have been developed in the United States. On one extreme of this spectrum are highly analytical programs which place a strong demand on the student's ability to deal in abstract mathematical terms. Programs in this area are often called Engineering Science. On the other extreme are programs that are related to specific areas of application and therefore place greater emphasis on descriptive knowlendge rather than mathematical skills. Programs in this area are generally called Engineering Technology or Technology. In order to best serve the needs of its student body the College of Engineering offers programs distributed within this wide spectrum. Although the emphasis within each program is specific and technical, each program has the educational breadth that distinguishes the professional from the technician.

As distinguished from the pure scientist who generally works on basic research, the engineer is generally a practitioner. As a practitioner the engineer must be able to identify problems, creatively design solutions, build and implement. In the practice of the profession, the engineer will be called on to combine knowledge of science, mathematics, and "state of the art" with judgement based on experience in order to develop economic and socially acceptable ways to use the available resources for the benefit of mankind. The professional is constantly searching for a better way, a better design, a more imaginative and effective system.

The educational objective of the College of Engineering is to prepare students for entrance into the profession of engineering. In recognition of the complexity of the profession, the program has been designed to allow students to elect to enter the practice of engineering after completion of an undergraduate degree or to delay entrance until they have obtained a graduate degree. Faculty advisors are assigned to each student in order to provide experienced guidance to the student in the selection of his particular program.

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CHEMICAL ENGINEERING

Chemical Engineering is the only engineering discipline based on the science of chemistry, although it is broadly rooted in the other scientific disciplines as well. It combines elements of most of the other engineering disciplines and applies chemistry and engineering to industrtial problems through the concepts of unit operation and unit processes.

The chemical process industries have provided a strong and continued growth with an ever-increasing demand for chemical engineering graduates. Current shortages of chemical engineers are expected to persist for many years to come, leading to substantial increases both in opportunities and in financial rewards. The stability and dynamic growth of the chemical and allied industries opens up unparalleled challenges and growth prospects to the chemical engineer. Emphasis is placed on the responsibility of the chemical engineer to protect the environment. The broad chemical and engineering training provided in this curriculum offers the graduate opportunities to enter Research and Development, Production, Sales, Marketing and General Management. It also gives him the tools to develop a career both stimulating and satisfying.

The student obtains a strong scientific background in the first two years, followed by two years of training in the discipline and related subjects. The curriculum provides maximum flexibility and allows for individual and original research if the student wishes. Considerable emphasis is placed on oral and written expression so necessary in the business world. Plant trips provide the essential link between theory and practice. Summer experience in the chemical industry is fostered. The student can enter either industry or graduate school upon graduation.

Students have the option to elect twelve hours of technical elective in the area of application of Chemical Engineering to the processes of the pulp and paper industry. These four courses are available in the senior year.

This curriculum is accredited by the Engineers' Council for Professional Development (ECPD).

SOPHOMORE YEAR

First Semester

CH	223	Organic Chemistry	(3-0)3
CN	203	Introduction to Chem. Eng.	(3-3)4
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	215	Analytic Mechanics I	(3-0)3
		General Elective	(3-0)3
		Total Hours	(17-3)18

Second Semester

CH	224	Organic Chemistry	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-0)2
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		General Elective	(3-0)3
		Total Hours	(17-3)18

JUNIOR YEAR

First Semester

MA	301	Adv. Calculus for Applications	(3-0)3
CN	305	Transport Phenomena I	(3-0)3
CN	311	Chemical Engineering Thermodynamics I	(3-0)3
CN	315	Unit Operations Laboratory I	(0-3)1
EE	348	Electrical Engineering Concepts	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

Second Semester

CH	336	Physical Chemistry	(3-3)4
CN	306	Transport Phenomena II	(3-0)3
CN	310	Separation Processes	(3-0)3
CN	408	Material Science	(3-0)3
CN	316	Unit Operations Laboratory II	(0-3)1
		Technical or General Elective	(3-0)3
		Total Hours	(15-6)17

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	409	Economic Process Analysis	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective or General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may elect AS 401

Second Semester

CN	410	Plant Design	(3-0)3
CN	414	Process Dynamics and Control	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective or General Elective	(3-0)3
		Technical Elective or General Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may elect AS 402

Six General Electives (18 semester hours) required in Chemical Engineering.

Students electing paper options are required to elect in place of twelve hours of technical elective in the senior year, the following courses:

CN	401	Engineering Analysis of Pulp and Paper Systems	(2-3)3
CN	402	Engineering Analysis of Coating and Converting Systems	(2-3)3
CN	404	Process Calculations of Pulp and Paper Processes	(3-0)3
CN	405	Economic and Environmental Analysis of Paper Systems	(3-0)3

CIVIL ENGINEERING

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and processing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes; and the adaptation of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are Civil Engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

SOPHOMORE YEAR

First Semester

CE	201	Surveying I	(3-4)4
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	201	Graphics	(0-3)1
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-9)17

Second Semester

CE	202	Surveying II	(3-4)4
LL	210	Technical and Scientific Communication	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	362	Numerical Analysis	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
		Total hours	(15-4)16

JUNIOR YEAR

First Semester

CE	311	Engineering Materials	(2-3)3
CE	313	Structural Analysis	(3-3)4
EC	201	Economics I	(3-0)3
ME	309	Dynamics I	(3-0)3
		General	(3-0)3
		Total hours	(14-6)16

Second Semester

CE	314	Structural Design I	(3-3)4
CE	332	Hydraulics	(4-0)4
CE	342	Transportation	(3-3)4
EC	202	Economics II	(3-0)3
ME	347	Elements of Thermodynamics & Heat Transfer	(3-0)3
		Total hours	(16-6)18

FOURTH YEAR

First Semester

CE	421	Hydrology	(3-3)4
CE	431	Soil Mechanics I	(3-0)3
EE	348	Basic Electrical Engineering Concepts	(3-0)3
		General or Technical Elective*	(3-0)3
		CE Elective	3 or 4
		Total credit hours	16 or 17

*ROTC Students may elect AS 401

Second Semester

CE	432	Soil Mechanics II	(3-3)4
EC	414	Engineering Economy	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
		General Elective	(3-0)3
		General or Technical Elective*	(3-0)3
		CE Elective	3 or 4
		Total credit hours	17 or 18

*ROTC Students may elect AS 402

CIVIL ENGINEERING TECHNOLOGY

The following curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering Technology is available only to employees of the Commonwealth of Massachusetts and its political subdivisions as an In-Service Training Program. For regulations concerning this program and for subjects required prior to the following curriculum, consult the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

This curriculum is accredited by the Engineers' Council for Professional Development.

JUNIOR YEAR

Second Semester

CE	361	Advanced Surveying	(2-1)2
CE	971	Structures	(2-1)2
DP	930	Scientific Computer Programming — FORTRAN	(2-1)2
LL	962	American Literature	(3-0)3
PH	942	Physics	(3-2)4
		General Elective	(3-0)3
		Total hours	(15-5)16

SENIOR YEAR

First Semester

CE	991	Concrete Analysis and Design	(3-3)4
CE	992	Soil Mechanics	(3-3)4
CE	995	Engineering Laboratory	(0-3)1
EE	975	Basic Electricity	(3-3)4
		General Elective	(3-0)3
		Total hours	(12-12)16

Second Semester

CE	981	Structural Analysis & Design	(3-3)4
CE	982	Hydrology	(3-3)4
CE	994	Engineering Problems	(2-1)2
EC	414	Engineering Economy	(3-0)3
EE	978	Basic Electronics	(3-0)3
		Total hours	(14-7)16

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering. This curriculum is accredited by the Engineers' Council for Professional Development.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classrooms. Specialization at the undergraduate level is, in general, discouraged. The student wishing to specialize in a specific area of electrical engineering may, with special permission, modify the order of the required courses, provided all prerequisites are met, in order that he may enroll in a sequence of technical electives in his area of specialty. All of the required courses must be successfully completed however before the student can be recommended for graduation.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life.

Many of the courses required in the Electrical Engineering curriculum are heavily dependent upon rather sophisticated mathematical techniques. It is therefore recommended that a freshman seeking admission into the sophomore year of Electrical Engineering should have received grades of not less than C− in all freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory I	(4-0)4
EE	207	Basic Electrical Engineering Laboratory I	(1-3)2
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory II	(4-0)4
EE	208	Basic Electrical Engineering Laboratory II	(1-3)2
MA	204	Calculus IV	(3-0)3
ME	212	Introductory Mechanics	(4-0)4
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EE	311	Electronics Laboratory I	(1-3)2
EE	327	Programming and Application of Digital Computers I	(2-0)2
EE	355	Introductory Electromechanics	(3-0)3
EE	365	Electronics I	(3-0)3
MA	315	Complex Variables for Engineers	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

Second Semester

EE	312	Electronics Laboratory II	(1-3)2
EE	328	Programming and Application of Digital Computers II	(2-0)2
EE	360	Electromagnetic Theory I	(3-0)3
EE	362	Signal and System Analysis	(3-0)3
EE	366	Electronics II	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

SENIOR YEAR

First Semester

EE	413	Linear Feedback Systems	(3-0)3
EE	461	Electromagnetic Theory II	(3-0)3
ME	347	Elements of Thermodynamics aand Heat Transfer	(3-0)3
		Electives*	4
		Technical Elective	3
		Total credit hours	16

*ROTC students may elect AS 401 for three hours.

Second Semester

	General Elective	(3-0)3
	Electives*	12
	Total credit hours	15

*ROTC students may elect AS 402 for three hours.

MECHANICAL ENGINEERING

Mechanical engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and automatic controls (electricity, electronics, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, technical electives are provided. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	271	Machine Tool Laboratory	(1-3)2
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)17

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	206	Mechanical Engineering Laboratory I	(0-3)1
ME	220	Mechanics of Materials I	(3-0)3
ME	242	Thermodynamics	(3-0)3
		Total hours	(14-6)16

JUNIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
MA	301	Advanced Calculus for Applications	(3-0)3
ME	307	Mechanical Engineering Laboratory II	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	320	Machine Design I	(2-3)3
ME	382	Fluid Mechanics I	(3-0)3
		Total hours	(14-6)16

Second Semester

C	202	Economics II	(3-0)3
E	308	Mechanical Engineering Labroatory III	(0-3)1
E	343	Heat Transfer	(3-0)3
E	354	Dynamic Systems	(3-0)3
E	395	Materials Science	(3-0)3
		General Elective	3
		Total hours	16

SENIOR YEAR

First Semester

ME	407	Mechanical Engineering Laboratory IV	(0-3)1
ME	424	Case Studies in Design	(1-3)2
ME	453	Senior Project I	(0-3)1
ME	497	Automatic Control Systems	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Elective*	3
		Total credit hours	16

*ROTC students may elect AS 401

Second Semester

ME	413	Gas Dynamics	
		or	(3-0)3
ME	474	Thermodynamic Applications	
ME	454	Senior Project II	(0-6)2
		Technical Elective	3
		Technical Elective	3
		General Elective	3
		Elective*	3
		Total credit hours	17

*ROTC students may elect AS 402

APPROVED TECHNICAL ELECTIVES

EC	414	Engineering Economy	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
MA	362	Numerical Analysis	(3-0)3
MA	452	Application of Numerical Analysis	(3-0)3
ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	428	Kinematic Mechanism Synthesis	(3-0)3
ME	462	Engineering Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	473	Mechanics of Materials II	(3-0)3
ME	475	Physical Metallurgy	(3-0)3
ME	477	Composite Materials	(3-0)3
ME	480	Advanced Projects in Systems and Design	(1-6)3
ME	483	Aerodynamics	(3-0)3
ME	488	Environmental Conditioning	(3-0)3
ME	500	Series subjects open to undergraduates by Department Approval.	

Other subjects may be taken as Technical Electives with the approval of the Advisor.

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry, strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics and quality control augment the basic courses in mathematics, sciences and engineering to round out a well-balanced program in Plastics Technology.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the international Society of Plastic Engineers, an opportunity which affords every student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry I	(3-0)3
CH	225	Introductory Organic Chemistry Lab. I	(0-4)1
MA	203	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
PH	201	Physics III	(4-2)4
PL	201	Polymeric Materials I	(2-2)3
		Total credit hours	(15-8)17

Second Semester

CH	224	Introductory Organic Chemistry II	(3-0)3
CH	226	Introductory Organic Chemistry Lab. II	(0-4)1
ME	216	Analytic Mechanics II	(3-0)3
L	210	Technical and Scientific Communication	(3-0)3
PL	202	Polymeric Materials II	(2-2)3
PL	204	Process Control Systems	(3-0)3
		Total credit hours	(14-6)16

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
ME	373	Plastics Mold and Die Design	(2-2)3
PL	301	Polymeric Materials III	(2-2)3
		General Elective	3
		Total credit hours	16

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
EC	202	Economics II	(3-0)3
ME	376	Plastics Mold Design and Construction (Optional)	(0-3)1
PL	302	Polymeric Materials IV	(2-2)3
		General Elective	3
		General or Technical Elective	3
		Total credit hours	16 or 17

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
PL	401	Plastics Processing I	(2-0)2
PL	403	Physical Properties of Polymers	(2-2)3
PL	405	Methods of Polymer Characterization	(2-0)2
PL	411	Plastics Seminar	(1-0)1
PL	413	Senior Projects I	(0-2)1
		General or Technical Elective*	3
		Total credit hours	16

*ROTC students may elect AS 401

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
PL	402	Plastics Processing II	(2-0)2
PL	404	Physical Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
PL	414	Senior Projects II	(0-2)1
		General or Technical Elective*	3
		General Elective	3
		Total credit hours	17

*ROTC students may elect AS 402

General Electives

Humanities — 9 credits required.

Recommended Technical Electives

ME	271	Machine Tool Laboratory	(1-3)2
ME	395	Material Science	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
PL	406	Polymer Structure	(3-0)3
PL	407	Plastics Industry Organization	(3-0)3

CHEMICAL ENGINEERING

CN 203 Introduction to Chemical Engineering (3-3)4
[CH 102, MA 104]

Introduction to the field of chemical engineering. Units and dimensions used by engineers. Flow sheets. P-V-T relationships and the Gas Laws. Introduction to mass balances. Laboratory: calculating devices including Wang Calculator; library investigations; fluids flow laboratory; chemical engineering equipment and its use; technical reports.

CN 204 Chemical Engineering Calculations (3-0)3
[CN 203, MA 204 taken concurrently]

Mass and Energy balances, including phase separation and elementary thermochemistry. Steady-state calculations and applications to chemical engineering processes. Introduction to unsteady-state concepts.

CN 206 Fluid Mechanics (2-0)2
[CN 203]

Introduction to fluid statics and application of fluid mechanics principles to the analysis of and design of fluid systems. Design of fluid meters and conduits. Friction factor, pressure drops in laminar and turbulent flow and introduction to boundary layer theory.

CN 305 Transport Phenomena I (3-0)3
[CN 206, MA 204]

Macroscopic and differential momentum balances applied to the solution of viscous flow problems in laminar and turbulent flow. The same analysis is applied to energy balances and the solution of those equations in conduction heat transfer problems.

CN 306 Transport Phenomena II (3-0)3
[CN 301, CN 305]

Convective energy transport mechanisms and the application of those equations in the design of heat transfer equipment. Radiant energy transport. Introduction of mass transfer equations and the development of the molecular convective diffusion in binary mixtures.

CN 310 Separation Processes (3-0)3
[CN 305; CN 306 taken concurrently]

Introduction to the design of multicomponent stage processes, such as distillation, absorption, extraction and humidification.

CN 311 Chemical Engineering Thermodynamics I (3-0)3
[CN 305 taken concurrently]

Application of the First and Second Laws of Thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 312 Chemical Engineering Thermodynamics II (3-0)3
[CN 311]

A detailed rigorous treatment of topics not covered in CN 311. Additional material on general thermodynamic relations are developed for use in application of non-ideal gases and real substances. Interpretation of phase equilibrium data and applications are covered, as well as an introduction to statistical thermodynamics.

CN 315-316 Chemical Engineering Laboratory (0-3) (0-3)2
[CN 305 and CN 306 taken concurrently]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports. Application of chemical engineering principles.

CN 319 Special Projects Credits to be arranged
[Approval of Instructor]

Research projects to be undertaken by the student with the supervision of a staff member. Usually will be an original problem. Reports required on project work.

CN 401 Engineering Analysis of Pulp and Paper Systems (2-3)3

Lectures dealing with processes of fiber separation from raw materials, fiber purification, mechanical processing of fiber and sheet formation. Chemical Engineering theory is applied to the analysis of these operations. Laboratory projects are conducted to evaluate various process variables.

CN 402 Engineering Analysis of Coating and Converting Systems (2-3)3

Lectures and problems concerned with the engineering design, technology and economics of paper and paperboard processes. Rheology and engineering properties of coating materials. Mechanical processes, coating, impregnating, laminating and printing processes are discussed in detail.

CN 403 **Reactor Design and Kinetics** **(3-0)3**
[CN 306]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems. May be taken for graduate credit.

CN 404 **Process Calculations of Pulp and Paper Processes** **(3-0)3**

Mathematical analysis of various processes using energy and material balances. Application of theory to the design of paper of various structure and properties.

CN 405 **Economic and Environmental Analysis of Paper Systems** **(3-0)3**

Economic and environmental concepts affecting the paper-making processes. Methods of analysis and interpretation of available data. Particular emphasis on stream pollution measurements, air pollution and monitoring devices for various processes.

CN 408 **Material Science** **(3-0)3**
[Approval of Instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures. Corrosion and elementary electrochemistry. Structures of metals, non-metals, and polymeric materials. Structure of materials related to performance. May be taken for graduate credit.

CN 409 **Economics and Process Analysis** **(3-0)3**
[CN 304, MA 204]

Analysis of selected chemical processes from the overall view of chemical engineering technology and basic economics. Time value of money concept. Methods of depreciation. Factors of cost in a) plant design, b) plant operation. Term problems involving computer-based solutions.

CN 410 **Plant Design** **(3-0)3**
[CN 409]

Application of unit operations; economics and process analysis in the design of complete chemical plants. Flow sheets, specifications for equipment and an economic estimate of the total plant cost is required for successful completion of the course.

CN 414 Process Dynamics and Control (3-0)3
[CN 204, CN 301]

An introduction to chemical process control, description of processes and equipment by differential equations and the LaPlace transform. Representation of open and closed loop by block diagrams. Control loop stability is discussed together with methods of representing dynamic behavior on Bode and Nyquist diagrams and related to experimental data. May be taken for graduate credit.

CN 419 Special Senior Projects Credits to be arranged
[Approval of Instructor]

Original research projects primarily in the chemical engineering field and supervised by a staff member of the Department. Reports required on work done.

CN 420 Analog Computer Techniques (3-0)3
[MA 301]

Application of analog computer concepts in the solution of chemical engineering and process dynamics problems. Use of the Department's EAI 380 analog computer is emphasized.

CN 503 Absorption and Extraction (3-0)3
[MA 301]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems. Use of computer in some problem solutions.

CN 506 Colloid Chemistry for Chemical Engineers (3-0)3
[Approval of Instructor]

Colloid chemistry principles applied to chemical engineering processes. Zeta potential and its applications; special problems involving surface chemistry and physics.

CN 507 Corrosion and Electrochemical Principles (2-0)2
[Approval of Instructor]

Electrochemical principles and physical chemistry relating to corrosion of metals. Materials of construction and design based on these principles. Prediction of metal behavior in process design.

CIVIL ENGINEERING

CE 201 **Surveying I** **(3-4)4**
[MA 103, ME 201 Concurrently]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 202 **Surveying II** **(3-4)4**
[CE 201]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering.

CE 311 **Engineering Materials** **(2-3)3**
[CH 102, ME 220]

A treatment of the properties of engineering materials as such influence the design, construction and maintenance of Civil Engineering works. Included are such materials as ferrous and non-ferrous metals, timber, plastics, and cementitious materials. Also includes the description and identification of soils. Supplemented by laboratory testing of various engineering materials.

CE 312 **Structures I** **(3-0)3**
[ME 220]

An introduction to the principles of structural analysis with applications to typical Civil Engineering structures. Emphasis will be on the analyses of statistically determinate planar structures.

CE 313 **Structural Analysis** **(3-3)4**
[ME 220]

Principles of structural analysis applied to typical civil engineering structures as the initial step in the total design concept. Basic emphasis on the analysis of statistically determinate structures with elements of modern methods of analysis of indeterminate structures. The digital computer as an analytical tool.

CE 314 **Structural Design I** **(3-3)4**
[CE 311, CE 313]

An introduction to the basic design of timber, steel and concrete structural members to resist axial force, shear and bending

moment. Elastic and inelastic design procedures. Use of codes as design standards.

CE 322 **Hydraulics** **(4-0)4**
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits. An introduction to the basic concepts of hydrodynamics and hydraulic similitude.

CE 342 **Transportation** **(3-3)4**
[CE 202, CE 311]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic and materials of construction.

CE 411 **Structures II** **(3-3)4**
[CE 312]

Analysis of statically indeterminate Civil Engineering structures employing classical and modern methods and treated as the initial steps in the total design concept.

CE 412 **Structures III** **(3-3)4**
[CE 411]

Design of structural elements and connections subjected to all types of stresses. Use and critical review of current design codes and application of these design principles to typical structures.

CE 413 **Concrete** **(3-3)4**
[CE 411 Concurrently]

Fundamental principles and concepts essential to the design and analysis of reinforced concrete structures. Research and its influence on design codes, study of elastic and inelastic behavior, and treatment of the rational foundations of design.

CE 421 **Hydrology** **(3-3)4**
[CE 322]

Theoretical principles underlying the use of the hydrologic phenomena of precipitation and water losses in the analysis and design of hydraulic structures. Methods of estimating stream flow under normal and flood conditions.

CE 431 Soil Mechanics I (3-0)3
[CH 102, CE 312 or CE 313]

Development of the fundamental principles of the science of soil mechanics as utilized in foundation engineering. Includes bearing capacity, percolation properties and settlement characteristics of soils as they affect the design of Civil Engineering structures.

CE 432 Soil Mechanics II (3-3)4
[CE 431]

Advanced theory of soil mechanics and its application to engineering analysis and design. Includes earth pressure theories, slope stability analysis, and the design of retaining structures and embankments. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties and behavior.

CE 441 Transportation Planning (2-3)3
[CE 342]

The principles and techniques involved in the various stages of comprehensive planning of transportation facilities. Preliminary engineering studies of route locations aided by use of aerial photographs and with full accountability of environmental influences. Includes the basic concepts of transportation economics, finance and administration.

CE 442 Transportation Systems (3-0)3
[CE 342]

The application of systems approach to problem solving in transportation engineering. The basic concept in systemization; the components, the classification, operational factors, and its application to planning. Special attention to terminals and traffic systems.

CE 453 Sanitary Engineering I (3-0)3
[CE 322]

Physical and chemical principles of water treatment and their practical application to purification systems. The several system components of treatment plants are studied to provide a basis for design capability.

CE 454 Sanitary Engineering II (2-3)3
[CE 322, CE 421]

Presents basic principles of design of water supply and waste water systems with emphasis on determination of design flows

and system performance. The laboratory will present fundamental tests and analytic procedures essential to sanitary engineering design and practice.

CE 961 Advanced Surveying (2-1)2

[45.32]

[For students in Engineering Technology only]

Application of higher surveying techniques to the providing of information and the solution of engineering problems. Topics covered include precise measurement of distances; precision measurement of angles; methods of determining elevations with high precision; consideration of photogrammetric techniques; and the basic principles of engineering astronomy.

CE 971 Structures (2-1)2

[25.52]

[For students in Engineering Technology only]

Review of elementary analysis of determinate structures with applications to more complex structures. Influence lines and their applications. Calculation of deflections of beams, frames and trusses. The analysis of indeterminate beams, trusses and simple frames by currently applicable methods.

CE 981 Structural Analysis and Design (3-3)4

[CE 971, 45.52]

[For students in Engineering Technology only]

Analysis and design of beams and frames. Design of structural elements under typical stresses by use of current design codes.

CE 982 Hydrology (3-3)4

[25.46]

[For students in Engineering Technology only]

A practical treatment of the occurrence and distribution of rainfall, surface and groundwater flow. Use of hydrologic factors as components in the design of hydraulic structures.

CE 991 Concrete Analysis and Design (3-3)4

[25.53]

[For students in Engineering Technology only]

The review and extension of the application of current methods to the analysis and design of reinforced concrete structures. Use of design aids to facilitate the solution of selected problems.

CE 992 **Soil Mechanics** **(3-3)4**

[CE 971]

[For students in Engineering Technology only]

Introduction to soil mechanics including laboratory techniques, all with the emphasis on the application of principles. Encompasses the use of field and laboratory tests in the design of foundations and the treatment of highway embankments. Laboratory work includes soil classification, graduation tests, Atterberg limits, and the common soil strength and compressibility tests.

CE 994 **Engineering Problems** **(2-1)2**

[For students in Engineering Technology only]

Topical discussions covering the relationship of the engineer to such groups as the general public, governmental agencies, clients and contractors, legal entities, and other engineers. Case studies include engineering concerns in such areas as contracts and specifications, regulatory agencies including zoning boards, boards of appeals, and conservation agencies.

CE 995 **Engineering Laboratory** **(0-3)1**

[CE 971]

[For students in Engineering Technology only]

Introduction to the basic techniques in the testing of engineering materials to establish experimentally the basic stress and strain indices. Introduction to experimental stress analysis by laboratory methods.

NOTE: All numerical prerequisites will be found in the catalogue of the Division of Evening Studies.

ELECTRICAL ENGINEERING

EE 201 **Introductory Circuit Theory I** **(4-0)4**

[MA 104, PH 201 concurrently]

Terminal characteristics of ideal elements, active and passive. Ohm's Law and Kirchhoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis. Definition and consequences of linearity, superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits, Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics,

energy relations, graphical differentiation and integration. First-order transients: initial conditions, natural response and natural frequencies. Network response to unit step function and unit impulse. Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane.

EE 202 Introductory Circuit Theory II (4-0)4
[EE 201]

Sinusoidal forcing function, complex numbers, phasors, sinusoidal steadystate. Average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton's theorems, superposition, reciprocity, maximum power and Tellegen's theorem in the frequency domain. Magnetic coupling, mutual inductance, ideal transformer. Impedance and admittance and hybrid parameters for a two-port network. Introduction to matrices and their use in circuit analysis.

EE 207 Basic Electrical Engineering Laboratory I (1-3)2
[EE 201 concurrently]

Experimental work designed to verify theory and to acquaint students with electrical measurement techniques: experiments on dc meters, bridges, and oscilloscopes. Remainder of experiments are correlated with course EE 201 and concern: resistive measurements, Kirchhoff's Laws, network theorems, conservation of power and maximum power transfer, inductance and capacitance, and first and second-order transients.

EE 208 Basic Electrical Engineering Laboratory II (1-3)2
[EE 207, EE 202 concurrently]

Experimental work designed to emphasize electrical measurement techniques of linear systems with time-varying signals. Waveform measurements with dc and ac meters as well as advanced use of the oscilloscope with experiments integrated with course EE 202. Experiments concern: Kirchhoff's Laws for phasors, magnitude and phase measurements of impedance, network theorems, frequency response, resonance, inductance and transformers, and maximum power transfer.

EE 211 Fundamentals of Electricity (3-0)3
[MA 104, PH 201 concurrently]
[Not open to students majoring in Electrical Engineering]

An introduction to electric circuits. Direct-current circuits,

network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state ac circuits, two-terminaal networks, and two terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]
[Not open to students majoring in Electrical Engineering]

A background subject in electronics presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211 or EE 348 concurrently]
[Not open to students majoring in Electrical Engineering]

An introductory laboratory course primarily devoted to the measurement of terminal characteristics of electrical machinery.

EE 311 Electronics Laboratory I (1-3)2
[EE 319 concurrently]

A laboratory course which explores the use of dual trace and differential amplifiers as oscilliscope plug-in units and other electronic test equipment in the investigation of static and dynamic characteristics of the vacuum triode, the solid state diode, and the bipolar transistor. In addition experiments in solid-state physics are performed. The experiments in this course are closely coordinated with the subject material in course EE 319.

EE 312 Electronics Laboratory II (1-3)2
[EE 320 concurrently]

The laboratory experiments in this course are closely coordinated with the subject material in course EE 320. Experiments covering the following subject areas are performed: biasing configurations and stability for bipolar transistors, single stage bipolar and field effect transistor amplifiers, differential amplifiers, feedback amplifiers, and linear integrated circuits.

EE 327 Programming and Application of Digital Computers I (2-0)2
[EE 202]

Elementary computer organization and information flow concepts are developed. Number systems are reviewed with emphasis on binary addition and subtraction. The theme of problem interpretation and analysis is stressed through program flow charting, coding, and documentation. FORGO and FORTRAN II-D programming languages are used to solve problems involving numerical integration, series solutions, list sorting, array manipulation, and elementary matrix operations. The interpretation and verification of computer results are stressed.

EE 328 Programming and Application of Digital Computers II (2-0)2
[EE 327]

The Boolean representation and the hardware implementation of the basic logical operations, half-adders and full-adders are developed. An introduction to programming techniques required in the development of large programs with emphasis on user-developed main programs that link disk-stored subprograms. Topics include definite and indefinite numerical integration, piecewise-linear function generation, first-order linear and nonlinear differential equations, simultaneous equations with real variables, determination of the magnitude and phase of rational functions, time-domain and frequency-domain plots.

EE 348 Basic Electrical Engineering Concepts (3-0)3
[MA 104]
[Not open to students majoring in Electrical Engineering]

An introduction to the basic principles of electricity, including the concept of voltage, current, resistance, inductance and capacitance; Ohm's and Kirchhoff's Laws; Thevenin's and Norton's Theorems. Emphasis will frequently be placed on pointing out analogous problems in the chemical and mechanical engineering fields. Other areas of coverages will include transient and sinuosoidal steady state analysis of RLC circuits, motor and generator concepts and an introduction to solid state devices including the semiconductor diode and transistor.

EE 351 Industrial Electronics (3-0)3
[MA 104]
[Not open to students majoring in Electrical Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum tube, gaseous-tube and semiconductor device characteristics and of circuits utilizing such devices for the purpose of rectification, amplification, and oscillation; and industrial photo-electric and time delay relays.

EE 355 Introductory Electromechanics (3-0)3
[EE 202]

Introduction to magnetic circuits, energy in magnetic circuits, forces and torque in electromagnetic devices, power and communication transformers with equivalent circuits, frequency response, and losses. Electromechanical energy conversion principles and electromechanical transducers.

EE 360 Electromagnetic Theory I (3-0)3
[MA 204]

An intermediate course in electrostatics and magnetostatics using vector calculus. Topics include: the electric field, line and surface integrals, potential, the divergence theorem, Gauss law, capacitance, conductors, dielectrics, Poisson's and Laplace's equations, the Biot-Savart law, Stokes's theorem, scalar and vector magnetic potentials, force and torque on conductors, magnetic circuits and inductance.

EE 362 Signal and System Analysis (3-0)3
[EE 202, MA 204]

Natural and forced response of linear systems; exponential excitation, impulse response, and system function. Fourier series analysis, impulse method of coefficient evaluation. Fourier transforms, complex Fourier transforms and Laplace transforms applied to linear systems analysis. Paley-Wiener criterion and causality. Distortionless ideal filters. Time-convolution in linear systems.

EE 365 Electronics I (3-0)3
[PH 201, EE 202]

Brief introduction to electronics using vacuum tube models and circuits, conduction mechanism, distribution, and flow of charge carriers in semiconductors. Junction diode physical electronics, diode circuits and models, theory of bipolar transistors leading to Ebers-Moll and hybrid-π models. Introduction to use of total and incremental bipolar transistor models.

EE 366 Electronics II (3-0)3
[PH 201, EE 202]

Theory of MOSFET and JFET leading to development of total and incremental models, determination of incremental parameters and biasing of bipolar, MOSFET, and JFET transistors. Low frequency and high frequency response calculations, multistage amplifiers, feedback amplifiers.

EE 403 Microwave Design Theory (3-0)3
[EE 461]

An introductory course in the analysis and design of passive microwave devices beginning with a review of time-varying electromagnetic field concepts and transmission lines. Impedance matching techniques, terminations, attenuators, phase changers, directional couplers, hybrids. Microwave devices employing Faraday rotation, electromagnetic resonators. Periodic structures. Microwave filter design.

EE 409 — Project Laboratory I — (0-4)2
[Permission of Instructor]

The purpose of this course is to provide an opportunity for qualified electrical engineering seniors to investigate specific areas of interest. Interested students apply for specific projects as advertised by staff members. At the discretion of the staff, students are assigned as individuals or team members to the projects. The projects themselves are research and development oriented and usually involve a substantial amount of laboratory work. A practical attitude and environment is maintained for the duration of the project. Design reviews, progress reports, and a final report is expected for each project.

EE 410 — Project Laboratory II — (0-4)2
[Permission of Instructor]

The purpose of this course is to provide an opportunity for a student to either continue his investigation undertaken in EE 409 or to initiate a new project which is not related to his EE 409 work.

EE 411 — Logic Design of Digital Systems I — (3-0)3
[EE 328]

An extension and elaboration of the number system, Boolean algebraic, and combinatorial logic concepts introduced in EE 328. An introduction to threshold and majority logic. Minimization techniques including Boolean algebraic manipulation, the Karnaugh map method, and the Quine-McCluskey tabular method. Simplification techniques are also applied to multiple output circuits and incompletely specified functions. Additional topics include basic digital system building blocks such as the adder and shift register, error detection and correction codes, and an introduction to sequential machines.

EE 412 — Logic Design of Digital Systems II — (3-0)3
[EE 411]

The general characteristics of finite synchronous and asynchronous sequential machines. State diagrams, state tables, implication tables and graphs are used to determine equivalent states and therefore equivalent minimal sequential machines. State assignment and complete machine logic design. Hazards in combinational and sequential networks. Introduction to neural networks, Turing machines, and automata.

EE 413 Linear Feedback Systems (3-0)3
[EE 362]

Concept of feedback: open loop and closed loop systems. Feedback in electrical, mechanical, biological, economic and social systems. Mathematical models of systems and linear approximations. Transfer functions of linear systems, block diagrams and signal flow graphs. Sensitivity, control of transient response, disturbance signals. Time domain performance: steady state errors, performance indices. Stability related to s plane location of the roots of the characteristic equation. Routh-Hurwitz criterion. Graphical analysis techniques: root locus, frequency response as polar plots and Bode diagrams. Closed loop frequency response and Nichols chart.

EE 414 Feedback Control Systems (3-0)3
[EE 413]

Time domain analysis of feedback control systems, compensation, Truxal's synthesis procedure, complex control systems and ac carrier systems.

EE 416 Electronic Amplifier Circuits (3-0)3
[EE 320]

An integrated treatment of the analysis and design of electronic amplifiers. Topics such as noise, noise figure, intermodulation, intercept point, VSWR, and frequency response are covered. Emphasis is then placed on the choosing of electronic devices and circuit configurations based on amplifier and system design objectives.

EE 417 Absolute and Symbolic Programming (3-0)3
[EE 328]

An introduction to absolute and symbolic programming and coding fundamentals. Typical digital computer organization; breakdown of functional blocks including arithmetic unit, control unit, memory and input-output structure. Computer word formats; single and double precision, floating point and instruction words. Machine instructions and methods of execution. Symbolic coding. Address modification, index registers and looping. Subroutines, calling sequences and utility routines. Input-output programming, buffering, interrupt input-output. Macroinstructions. Table processing techniques. Programs will be run by students on the Electrical Enginering Department's HP 2116B computer.

EE 425 Wave Shaping and Generation I (3-0)3
[EE 320]

Principles and methods of wave shaping and wave genera-

tion using active and passive elements. Pulse transformers, delay lines, wideband amplifiers and steady-state switching characteristics of electronic devices. Clipping, comparator, clamping, and switching circuits. Logic circuits.

EE 426 Wave Shaping and Generation II (3-0)3
[EE 425]

Bistable, monostable and astable multivibrators. Negative resistance devices and switching circuits. Voltage and current time base generators. Blocking-oscillator circuits, sampling gates, counting and timing, synchronization and frequency division.

EE 429 Network Synthesis (3-0)3
[EE 362, MA 315]

Review of linear system analysis methods: consideration of natural frequencies for impedance-by-inspection techniques. Tellegen's theorem: general reciprocity relation and driving-point impedance characteristics. Positive-real functions: definitions and tests. Hurwitz polynomials and Sturm tests. Properties of LCT, RCT, RLT, and RLCT one-ports with Cauer, Foster, and Brune network realizations. Partial-pole removals and introduction to transfer function realizations.

EE 435 Special Topics in Electrical Engineering I (3-0)3
[Permission of Instructor]

An analytic consideration of one or more special topics selected from recent developments in the field of electrical engineering.

EE 436 Special Topics in Electrical Engineering II (3-0)3
[EE 435]

Continuation of EE 435.

EE 439 Introduction to Electrical Systems (3-0)3
[EE 362, EE 320]

Introduction to the basic theory underlying geographically large electrical systems such as power distribution networks and communication systems. Principles of amplitude modulation and its application to frequency-division multiplex systems. Effects of higher-order modulation products. Frequency and phase modulation and other forms of pulse modulation including their use in time-division multiplex systems. Survey of radio propagation.

EE 440 **Electrical Communication System** **(3-0)3**
[EE 439]

Advanced study of communication systems. Statistical properties of signals and noise. Power spectra and correlation. Thermal and shot noise. Noise figure and noise temperature. Detection of signals in noise. Introduction to information systems. Simple error-detecting codes and other theoretical problems in communication and radar systems.

EE 444 **Electrical Power Systems** **(3-0)3**
[EE 355]

Design and operation of present-day power networks considered both from the viewpoint of economy and reliability including the problems of power and frequency control, system stability and fault analysis.

EE 445 **Analog Devices and Techniques** **(3-0)3**
[EE 320]

A survey of analog devices and techniques. Primary emphasis is on general techniques although conventional analog computers are discussed extensively as examples of the application of the techniques. Operational amplifiers, multipliers, amplitude and time scaling.

EE 446 **Digital Devices and Techniques** **(3-0)3**
[EE 328]

A survey of digital services and techniques. Primary emphasis is on general techniques although conventional digital computers are discussed extensively as examples of the application of the techniques. Machine organization, number systems, Boolean algebra, arithmetic operations, memory devices, analog to digital conversion, and digital to analog conversion are discussed.

EE 461 **Electromagnetic Theory II** **(3-0)3**
[EE 360]

Extension of EE 360 to time varying fields. Topics include: Faraday's law, displacement current, Maxwell's equations, plane waves, Poynting's theorem, skin depth, transmission line theory, Smith chart, simple antennas.

EE 463 **Introductory Communication Theory** **(3-0)3**
[EE 362]

This course, a continuation of EE 362, involves a study of mathematical methods in communication theory. Topics considered are: temporal waveform multiplication and frequency

convolution applied to amplitude modulation. Hilbert transforms and SSB transmission. Introduction to angle modulation: Bessel functions, narrow and wideband FM. Sampling theorem and signal space and Z-transforms. Multiplexing in frequency and time domains. Pulse modulation: amplitude frequency, position and code (PCM). Signal comparison — correlation and energy spectral densities. Shot and thermal noise applied to linear systems and comparative analysis of communication systems with noise. Introduction to information theory.

EE 465 Direct Energy Conversion (3-0)3
[EE 355 or EE 454]

Review of first and second law of thermodynamics; thermoelectric, photoelectrics, and thermionic conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion. Nuclear fission, reactor theory, reactor control and operation, reactor shielding.

EE 471 Modern Energy Conversion Methods (3-0)3
[MA 204, PH 201]
[Not open to students majoring in Electrical Engineering]

Dc electromechanical energy conversion, synchronous converters, inductive energy conversion, transformers. Dynamic analysis using Lagrange's equations. Thermoelectric, thermionic and photoelectric energy conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion. This course is primarily intended to acquaint the nuclear enginer with the modern energy conversion methods available for use in conjunction with a nuclear reactor.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well qualified undergraduate students.

EE 503 Solid-State Physical Electronics I (3-0)3
[EE 360]

Introduction to the behavior of solid-state electronic devices from the viewpoint of modern physics: review of classical mechanics and Maxwell's equations. The Bohr atom, wave-particle duality, wave packets, Schroedinger's equation, band theory of solids, electrons and holes. Mechanical and acoustical properties of solids, semiconductor behavior.

EE 504 Solid-State Physical Electronics II (3-0)3
[EE 503]

Continuation of EE 503. Semiconductor devices: Schottky diodes, p-n junction devices, junction transistors, field-effect

transistors, photo-diodes, varactors. Electro-optic devices, thermo-electric devices, electro-luminescent diodes and laser diodes. Magnetism and magnetic devices.

EE 505 **Microwave Electronics I** **(3-0)3**
[EE 461]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers. klystrons, magnetrons, and traveling wave tubes.

EE 506 **Microwave Electronics II** **(3-0)3**
[EE 505]

Continuation of EE 505

EE 507 **Electromagnetics I** **(3-0)3**
[EE 461]

Solution of Laplace's and Poisson's equations in rectangular, cylindrical and spherical coordinates. Green's function and conformal transformations. Also boundary value problems, radiation, transmission lines and wave guides will be treated.

EE 508 **Electromagnetics II** **(3-0)3**
[EE 507]

Continuation of EE 507

EE 509 **Linear Systems Analysis** **(3-0)3**
[EE 362]

Classical solution of linear systems described by differential equations. Duals, analogs, and electromechanical systems. System function, step and impulse response, and initial conditions. Time-domain convolution. Fourier analysis, series, and integral: impulse method for obtaining transforms. Laplace transforms: evaluation and properties. Complex variable theory: complex differentiation and Cauchy-Riemann equations. Complex integration: Cauchy's theorem and Cauchy's integral formulas. Taylor and Laurent series and the residue theorem. Inverse Laplace transforms. Introduction to Z-transforms.

EE 510 **Systems Analysis-State Variable Techniques** **(3-0)**
[MA 533]
[Not open to students who have completed EE 577]

State variable formulation and solution of differential equations which arise in the treatment of mechanical, acoustica thermal, and electrical systems with consideration of canonic forms for computer simulation.

EE 515 **Nonlinear Control Systems** **(3-0)3**
[EE 413]

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function, the methods of Lyapunov and Popov and other nonlinear analysis techniques are treated.

EE 517 **Optimal Control Systems** **(3-0)3**
[EE 413]

A study of the analysis and design of optimal control systems. Both deterministic and random input signals are discussed. Introduction to adaptive control systems.

EE 519 **Discrete Data Control Systems** **(3-0)3**
[EE 413]

The sampling process, reconstruction of sampled signals, transforms, inverse Z-transforms and flow graph representation of digital systems. The state variable approach to discrete data systems, time solutions by state variable methods. Stability of discrete data systems. Introduction to optimal control of discrete data systems.

EE 521 **Automata Studies** **(3-0)3**
[EE 412]

Mathematical foundation of automata, including probabilisic logics, neuron analogs, Turing machines, and learning theory.

E 523 **Digital Computer Software** **(3-0)3**
[EE 563]

Examination of computer system software as an information rocessing function. Description of information structures. Foral languages, their syntax and semantics. Text processing proams and text editors. Assembly language and processing. Realne system softwave. Time sharing and program sharing techques in real-time systems.

525 **Simulation Techniques** **(3-0)3**
[EE 328, EE 445]

A study of modern analog, digital and hybrid techniques for te simulation of continuous and discrete systems and processes. e student is expected to study a number of practical engineerig systems through the use of simulation techniques on available alog, hybrid and digital computers.

EE 529 **Network Synthesis I** (3-0)3

[EE 362]

A review of natural frequencies and analysis techniques; complex variable topics such as conformal mapping, maximum modulus theorem, and Laurent series. Tellegen's theorem. Positive real (p.r.) functions developed from four different viewpoints, including reflection coefficients. Methods for testing p.r. functions; Hurwitz test, Sturm test, and residue tests. Quadratic forms and the testing for p.r. matrices. Properties of the driving-point and transfer immittances of LST, RCT, and RLT networks, Cauer and Foster network realizations, partial pole removals. Cauer transformations. RLCT Brune realizations.

EE 530 **Network Synthesis II** (3-0)3

[EE 529]

RLCT driving-point synthesis methods of Darlington, Bott-Duffin, Miyata and Fialkow-Gerst. Transfer synthesis methods of Darlington, constant-resistance lattice, RC ladder. Approximation problems using Butterworth functions, dissipation and predistortion techniques. An introduction to active network synthesis.

EE 537 **Introduction to Bio-Medical Engineering** (3-0)3

[EE 320]

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed.

EE 539 **Biological Systems** (3-0)3

[EE 413, EE 445, EE 537]

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required.

EE 545 **Coding Theory** (3-0)3

[MA 533]

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail.

EE 547 Statistical Communication Theory (3-0)3
[MA 584]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 584]

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

EE 549 Introduction to Lasers and Masers (3-0)3
[EE 360 or PH 353, EE 403]

A first course on Lasers and Masers not requiring quantum mechanics as a prerequisite. Classical electric and magnetic dipole models are developed to describe the quantum interaction between atoms or molecules and the radiation field. This course is designed to prepare the student to read the literature on the subject.

EE 551 Electro-Optics (3-0)3
[EE 362, EE 461, EE 549]

Principles of optical propagation as described by the Fresnel-Kirchhoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 552 Electro-Optics II (3-0)3
[EE 551]

Continuation of EE 551.

EE 561 Computer Organization and Design (3-0)3
[EE 411, EE 417]

A critical examination of the organization of present day digital computers from both the software and hardware points of view. Computer design with hardware-software trade-off. Comparison of instruction sets, their hardware implementation. Examination of the input-output structures of selected examples. Multi-processing and parallel processing. Detailed examination

of a large system and of several mini-computers. Students are expected to simulate certain aspects of the example computers on available digital computers.

EE 563 System Programming (3-0)3
[EE 417]

The definition of system programming as programming in a multi-user environment. Programming with and for interrupts. Reentrant programming, pure procedures. Communication between program modules. Nested calls, the push-down stack. Recursive program calls. Reentrant interrupt programming. Activation records and program sharing. Character and list handling routines. Input-output systems. Representative programs of the above topics will be programmed by the student in assembly language on the HP 2116B computer.

EE 571 Introduction to Radar Systems (3-0)3
[EE 439]

Introduction to both pulsed and C.W. radar systems. Detection of radar echoes in noise. The radar equation and its use in estimating performance of a radar system. Estimation of range, direction and velocity of targets. Moving target indicators (MTI). Pulse compression and other advanced techniques. Discussion of elements of practical radar systems.

EE 574 Digital Subsystem Design I (3-0)3
[EE 411, EE 417]

The definition of a particular digital subsystem in terms of a nested set of smaller subsystems, each performing a subset function such as data formatting, data buffering, data storage, synchronization, switching, and specialized algorithms. The relationship of the overall system to its environment is used to develop solution algorithms. The overall subsystem is decomposed into its subset functions and an algorithm is generated for each subset and subset interface. An evaluation of the cost, performance, and adaptability of each algorithm in both its hardware and software versions is performed as an aid to the designer in selecting the most feasible scheme for use in the detailed subsystem realization.

EE 575 Digital Subsystem Design II (3-0)3
[EE 574, EE 426]

An overview of the design process developed in EE 574 with emphasis on developing algorithms at the subsystem and subset function levels, decomposition of these algorithms into detailed

block diagrams showing registers, transfer paths, control and timing logic. A detailed logic diagram is developed for each hardware algorithm with factors such as speed, fan-in and fan-out, and the availability of complex logic functions controlled by the logic family selected. Digital subsystem projects include the design, bread-boarding and testing of peripheral interfaces or special application subsystems.

EE 577 State Variable Analysis of Systems (3-0)3
[EE 362]

Algebra of matrices, vector spaces and linear transformations. Calculus of matrices, matrix functions and the solution of differential and difference equations as formulated by the state variable characterization of systems. A consideration of canonical forms for computer simulation.

EE 581 Electrodynamics (3-0)3
[EE 355]

The main focus of this course is the transient anlysis of electromechanical devices, including electromechanical transducers and ac and dc machines. Topics covered include stored electric and magnetic energy, electric and magnetic forces, dynamic models of electromechanical devices, solution of differential equations to obtain equations of motion, driving point impedances, transfer functions for linear devices, and methods of approximation for nonlinear devices. Applications covered include magnetic transducers, piezo-electric transducers, transient analysis of power systems, and the formulation of mathematical models of servomechanism components.

EE 583 Dynamic Analysis and Control of Power Systems by Computers (3-0)3
[EE 328, EE 444]

Modern integrated electrical power systems are highly complex, and, to guarantee a high level reliability, the behavior of these systems is often analyzed using computer techniques. This course provides the student with the background necessary to perform such analyses. Topics include power system modeling for dynamic analysis, short circuit studies, computer simulation, and the application of numerical and direct methods to power system stability problems. Review of control theory and the application of optimization methods to the control of power systems.

EE 975 **Basic Electricity** **(3-3)4**

[PH 942, 45.41]

[For Engineering Technology students only]

An introduction to electric circuits for students who have a background in basic principles of electricity and magnetism. Includes illustrative laboratory projects.

EE 978 **Basic Electronics** **(3-0)3**

[EE 975]

[For Engineering Technology students only]

A background subject in electronics presenting the properties and applications of vacuum tube and semiconductor devices. Intended for the student who will use rather than design electronic circuits.

MECHANICAL ENGINEERING

ME 201 **Graphics** **(0-3)1**

The technique of communicating engineering information and concepts by means of orthographic drawings, pictorial views and sketches. Charts, graphs, graphical calculus, fundamentals of descriptive geometry.

ME 205 **Introduction to Engineering Design** **(2-3)3**

[ME 104]

The process of mechanical design, with emphasis on graphical communication and layout. Lectures on design, drawing, dimensioning, fasteners, gears, cams, bearings and manufacturing techniques. Laboratory experiences in sketching, layout and design drawing. Demonstrations of machine tool operations including numerical control. Students must complete a comprehensive design project.

ME 206 **Mechanical Engineering Laboratory I** **(3-0)1**

[ME 220, ME 242 Concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in mechanics of materials and thermodynamics.

ME 208 Introduction to Kinematics (3-0)3

A study of the basic principles of kinematics. Topics involved are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms. Available equipment serves as the basis of problems and assignments.

ME 211 Mechanics I (3-0)3

[MA 104, PH 101]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situations. The concept of stress and strain at a point. The stress-strain-temperature relations.

ME 212 Introductory Mechanics (4-0)4

[PH-203, MA-206, Concurrently]

Study of deformable solids, respond to mechanical loading, stress, strain, and elastic moduli for various materials. The study of dynamics and kinematics, Newton's second law including momentum and energy forms. Applications include rigid body motion, colliding particles, vibrating systems and electrical analogues, and central force systems.

ME 215 Analytic Mechanics I (3-0)3

[MA 104, PH 101]

[Primarily for CN, PL, and TE students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Analytic Mechanics II (3-0)3

[ME 215]

[Primarily for CN, PL, and TE students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 **Mechanics of Materials I** **(3-0)3**

[MA 203, ME 211, PH 102]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 242 **Thermodynamics** **(3-0)3**

[MA 203, PH 102]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability. Energy Conversion cycles.

ME 271 **Machine Tool Laboratory** **(1-3)2**

Lectures, demonstrations and laboratory experience in material processing. The student becomes familiar with the purpose and operation of industrial machine tools for turning, grinding, mill, shaping, and electrical discharge machining. Design and programming for numerical control, foundry practice, die-casting, welding.

ME 307 **Mechanical Engineering Laboratory II** **(0-3)1**

[ME 309, ME 382, ME 395, all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, fluid mechanics and materials science.

ME 308 **Mechanical Engineering Laboratory III** **(0-3)1**

[ME 343, ME 354, both concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics systems and heat transfer.

ME 309 **Mechanical Engineering Laboratory III** **(0-3)1**

[MA 204, ME 211, PH 102]

Vector development of kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. D'Alembert's principle. Impulse and momentum.

ME 315 Applied Mechanics (3-0)3

[MA 104, PH 101]
[Primarily for IM students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 Machine Design I (2-3)3

[ME 220, ME 309]

The principles of mechanics and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 343 Heat Transfer (3-0)3

[ME 242, ME 382]

Mathematical theory and applications of steady and transient heat conduction in solids. Heat transfer in convection and application to heat exchangers. Hydrodynamic and thermal boundary layer theory. Development of thermal radiation theory and its application to heat exchange with and without absorbing gases. Combined heat transfer by conduction, and radiation.

ME 344 Heat and Power (3-0)3

[MA 104, PH 102]
[Primarily for IM students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 347 Elements of Thermodynamics and Heat Transfer (3-0)3

[MA 203, PH 102]
[Primarily for CE, EE, and TE students]

A study of the first and second law of thermodynamics with application to system and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases.

ME 354 Dynamic Systems (3-0)3
[MA 301, ME 309]

Unified approach to the modeling of simple mechanical, electrical, thermal and fluid systems. Transient and steady-state response of first and second order systems via classical and Laplace transform techniques. Supporting laboratory exercises emphasize real system behavior and associated physical measurement problems; error analysis.

ME 372 Strength of Materials (3-0)3
[ME 315]
[Primarily for IM students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 373 Plastics Mold and Die Design (2-3)3
[Primarily for PL students]

The fundamentals and basic principles of mold and die design for injection, compression, transfer, thermoforming and extrusion processes. Design considerations will include metal selection, runner and gate construction for the various polymeric materials. Laboratory will consist of actual design of a mold or die, with emphasis on relative drafting.

ME 376 Plastics Mold Design and Construction (0-3)1
[ME 271, ME 373]
[Primarily for PL students]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the machines in the Department of Plastics Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 — Fluid Mechanics I — (3-0)3
[MA 301 concurrently]

Development of basic fluid mechanical relations; continuity, momentum and energy equations. Lagrangian v. Eulerian approaches. Applications to inviscid and viscous, incompressible flows. Similarity and dimensional analysis. Boundary layer concepts and mathematical description. Fundamentals of turbulence. Introduction to low speed aerodynamics. Development of angular momentum principles and their application to turbomachinery.

ME 395 — Materials Science — (3-0)3
[CH 102, PH 102]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 407 — Mechanical Engineering Laboratory IV — (0-3)1
[ME 413, ME 417, ME 497, all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, gas dynamics and automatic controls.

ME 413 — Gas Dynamics — (3-0)3
[ME 242, ME 382]

Thermodynamics of gas mixtures and chemical equilibrium. Extension of basic equations of motion and energy to inviscid, compressible flows. Acoustic equations. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Crocco's theorem. Prandtl-Meyer expansion. Method of characteristics. Linearized flow theory.

ME 417 — Dynamics II — (3-0)3
[MA 301, ME 309]

Work-energy relation. Conservative force fields. Impulse and Momentum. Conservation of energy. Generalized coordinates and Lagrange's Equations. Vibrations of single and multiple degree of freedom systems.

ME 419 Nondestructive Evaluation Techniques (3-0)3

[Senior Standing]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical and metallurgical properties. May be taken for Graduate Credit.

ME 422 Machine Design II (2-3)3

[ME 320]

A continuation of ME 320. Laboratory problems emphasize aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria. May be taken for Graduate Credit.

ME 424 Case Studies in Design (1-3)2

[ME 320]

Case studies of design problems from the case study library are investigated by the entire class. Smaller groups are then formed to study current industrial design problems. Reports on the studies are presented to the class.

ME 428 Kinematic Mechanism Synthesis (3-0)3

[ME 309]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis. May be taken for Graduate Credit.

ME 453 Senior Project I (0-3)1

[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members. The first term is devoted to problem definition, solution synthesis and design analysis.

ME 454 — Senior Projects II — (0-6)2

[Senior Standing]

A continuation of ME 453. The second term is devoted to trade off and optimization, contruction, testing, evaluation and reporting.

ME 462 — Engineering Analysis — (3-0)3

[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Problem examples include both discrete and continuous systems encountered in the fields of solid mechanics, fluid mechanics, heat transfer, and electrical networks. May be taken for Graduate Credit.

ME 468 — Fluid Machinery — (3-0)3

[ME 382]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-dimensional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation. May be taken for Graduate Credit.

ME 472 — Experimental Stress Analysis — (2-3)3

[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distribution by experimental methods. Photoelasticity, birefringent coatings, brittle coatings, analogies, strain gage applications, rosette analysis. May be taken for Graduate Credit.

ME 473 — Mechanics of Materials II — (3-0)3

[MA 301, ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center, unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections. May be taken for Graduate Credit.

ME 474 — Thermodynamic Applications — (3-0)3

[ME 242]

Application of the laws of thermoydynamics to power cycles

and refrigeration cycles. Multiphase mixtures. Thermoydynamics of reacting systems, equilibrium criteria, heats of reaction, completeness of reaction, dissociation. May be taken for Graduate Credit.

ME 475 Physical Metallurgy (3-0)3
[ME 395]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phenomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture. May be taken for Graduate Credit.

ME 477 Composite Materials (3-0)3
[ME 395]

The course devotes attention to three basic areas of composite materials, namely, analysis, fabrication, and applications. Micro and macromechanics of composite materials are considered and several fabrication techniques are considered for applications ranging from aircraft structures to fiberglass boats. May be taken for Graduate Credit.

ME 480 Advanced Projects in Systems and Design (1-6)3
[Senior Standing]

For the student desiring to carry on substantial projects of his own choosing in the areas of engineering design, systems or automatic controls. Special lectures and seminars to be arranged when appropriate. Projects arranged on an individual basis in consultation with instructor. May be taken for Graduate Credit.

ME 483 Aerodynamics (3-0)3
[ME 382]

Fundamentals of subsonic aerodynamics. Atmosphere models. Airfoil data, and lift and drag of aircraft components. Three dimensional wing theory and aspect ratio corrections. Aircraft performance, with an introduction to jet propulsion.

ME 488 Environmental Conditioning (3-0)3
[ME 242 or ME 347]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces. May be taken for Graduate Credit.

ME 497 Automatic Control Systems (3-0)3
[EE 212, MA 302, ME 354]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 530 Ultrasound, A Nondestructive Evaluation Method (2-3)3
[ME 395]

Propagation characteristics of ultrasound are developed and analyzed to indicate usefulness as a nondestructive method of evaluation. Equipment for generation detection and display. Scientific and engineering applications using velocity and attenuation measurements are stressed.

ME 531 Advanced Thermodynamics (3-0)3
[ME 242, MA 301]

A comprehensive treatment of the classical first and second law. Availability, criteria of equilibrium, heterogenous systems, mixtures and solutions, chemical equilibrium. Introduction to statistical methods as applied to evaluation of thermodynamic properties.

ME 534 Transport Processes (3-0)3
[ME 343]

Diffusive and convective transport of mass, momentum and energy. Free and forced convection in laminar and turbulent flows. High velocity flows, ablation, boiling and condensation.

ME 535 Advanced Heat Transfer (3-0)3
[ME 343]

Heat conduction: analytical and numerical solutions. Thermal stresses. Laws of thermal radiations. Combined modes of heat transfer. Heat transfer in the environment and in biological systems. Thermal pollution. Offered on alternate years.

ME 541 Advanced Fluid Mechanics (3-0)3
[ME 382]

Basic equations of incompressible flow. Flow in open chan-

nels. Water waves. Flow over airfoil; lift and drag. Creeping flow and theory of lubrication. Boundary layer. Introduction to the statistical theory of turbulence. Experimental techniques. Offered on alternate years.

ME 542 Advanced Gas Dynamics (3-0)3
[ME 382, ME 382]

Equations of motion for inviscid, compressible fluid. One-dimensional steady flow with area change, friction, heat transfer and combustion. Shock waves. Unsteady flows and wave phenomena. Similarity, characteristics, small disturbances, approximation procedures.

ME 544 Acoustics (3-0)3

Fundamentals of the propagation of sound in fluids, solids and structures. Included will be a development of the basic concepts and equations and the application of these to special topics such as physiology, underwater acoustics, and sound control. Offered on alternate years.

ME 552 Continuum Mechanics (3-0)3
[ME 220, ME 242, ME 382]

Stress and deformation in a continuum in tensor notation. Fundamental laws of mechanics and thermodynamics. Applications to elastic, viscous and viscoelastic substances.

ME 554 Theory of Elasticity (3-0)3
[ME 473, ME 551]

Formulation of the problem of elastic equilibrium. Torsion and flexure of prismatic bars, contact stresses, plane stress, plain strain and stress concentrations. Offered on alternate years.

ME 556 Theory of Inelastic Continuum (3-0)3
[ME 473, ME 551]

Development of the constitutive equations governing inelastic (anelastic, viscoelastic, plastic and visco-plastic) deformations. Theorems and boundary valve problems as applied to inelastic continua. Offered on alternate years.

ME 558 Plates and Shells (3-0)3

Variational methods are utilized to derive the plate and shell equilibrium equations including nonlinear effects and inertia terms. Solutions to bending, buckling, and vibration problems

are obtained for rectangular and circular plates. The membrane theory of shells as well as the general theory is investigated and solutions are obtained for a variety of practical shell problems.

ME 562 Advanced Dynamics (3-0)3
[ME 417]

Dynamics of mechanical systems by use of direct and variational methods. Three-dimensional rigid body dynamics, and vibrations of lumped parameter and continuous systems. Nonlinear and self-excited oscillations. Stability.

ME 564 Structural Dynamics (3-0)3
[ME 417]

Response of complex structures to deterministic and random excitations. Exact and approximate normal modes by energy, and by differential and integral methods. Proportional and non-proportional damping.

PLASTICS TECHNOLOGY

PL 201 Polymeric Materials I (2-2)3

A descriptive subject to acquaint the student with plastics as a class of materials. The history, classification, definition, raw materials, methods of manufacture, properties and uses of polymeric materials. Introduction to laboratory methods in the processing and fabrication of plastics materials.

PL 202 Polymeric Materials II (2-2)3
[PL 201 or Permission of Instructor]

A continuation of PL 201. Emphasis is placed on the engineering thermoplastics. Polymers for thermal extremes as well as many of the newer high performance plastics are also discussed. Introductory laboratory instruction is continued.

PL 204 Process Control Systems (3-0)3
[PH 102 or Permission of Instructor]

Basic principles of control systems used with plastics processing equipment. Included are hydraulic, pneumatic, electromechanical, pressure and temperature control devices.

PL 301 — Polymeric Materials III — (2-2)3

[PL 201, PL 202 or Permission of Instructor]

Analysis of additives including stabilizers, plasticizers, biocides, release agents, flame retardants, colarants and foaming agents as well as modifiers, fillers and reinforcing agents. Laboratory instruction of a more advanced nature in the processing and fabrication of plastics molding materials is introduced.

PL 302 — Polymeric Materials IV — (2-2)3

[PL 301 or Permission of Instructor]

Discussion of compounding techniques and the evaluation and development of typical plastics molding compounds. Survey of materials for reinforced plastics and composites, film and sheeting, adhesives, and non-plastics applications of polymers.

PL 401 — Plastics Processing I — (2-0)2

A theoretical and practical study of plastics process engineering. Correlation of composition, processing and fabrication with mold, product and equipment design.

PL 402 — Plastics Processing II — (2-0)2

A continuation of PL 401.

PL 403 — Physical Properties of Polymers — (2-2)3

[Open to seniors only]

Introduction to basic mechanical properties of polymers as linear viscoelastic materials. Concepts of creep, stress relaxation, and superposition principles emphasized. Important material parameters are obtained in laboratory sessions.

PL 404 — Physical Properties of Polymers — (2-2)3

[PL 403]

Dynamic mechanical behavior, interrelations between various properties, electrical behavior, miscellaneous mechanical properties, optical properties.

PL 405 — Methods of Polymer Characterization — (2-0)2

[Open to seniors only]

Survey of physical techniques used in the characterization of polymeric materials with respect to molecular weight, molecular weight distribution. stereo regularity, branching, glass and other transitions, ·ordering, crystallinity, orientation, fine structure and cross linking.

PL 406 **Polymer Structure** **(3-0)3**
[Permission of Instructor]

The fundamental relationships between molecular structure, properties and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical composition, molecular size and flexibility, intermolecular order and binding, and supermolecular structure. Properties include processability, mechanical, acoustic, thermal, electrical, optical and chemical properties, price, and balance of properties. Applications include rigid solids, flexible solids, foams, films, and non-plastic applications.

PL 407 **Plastics Industry Organization** **(3-0)3**
[Permission of Instructor]

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing, and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit and growth.

PL 409 **Senior Research in Plastics** **(1-6)3**
[Permission of Instructor]

Individual research projects in plastics chemistry, properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs and submit final reports for publication.

PL 410 **Senior Research in Plastics** **(1-6)3**

Continuation of PL 409.

PL 411 **Plastics Seminar** **(1-0)1**

Informal discussions based on literature study conducted by the individual of topics in or related to Plastics Technology.

PL 412 **Plastics Seminar** **(1-0)1**

A continuation of PL 411.

PL 413 Senior Projects I (0-2)1

Assignment of senior projects designed to develop the student's ability to organize and conduct investigations of materials performance and processing techniques.

PL 414 Senior Projects II (0-2)1

A continuation of PL 413.

THE COLLEGE OF MANAGEMENT SCIENCE

THE COLLEGE OF MANAGEMENT SCIENCE

The undergraduate degree programs of the College are amongst the newer curricula offered at the Institute. Their acceptance is confirmed by the fact that over one quarter of the undergraduates in the Institute are enrolled in them. A young dynamic faculty has established a number of major options that can equip students to be successful upon graduation in either their first professional employment or in graduate school.

The College is a member of the Assembly of the American Association of Collegiate Schools of Business and follows its educational standards. Students can expect an undergraduate program of the highest quality whether they select accounting, economics, the several management areas, or Industrial Management.

The following pages describe the curricula given by the College. Course descriptions in business administration, economics, and industrial management follow.

Information on the Master of Management Science program can be found in the Graduate School catalogue.

INSTRUCTIONAL STAFF

Dean of College

Stuart L. Mandell

Members

Jack D. Alexander, B.S. in B.A., M.A., M.A. (University of Notre Dame), M.B.A. (Harvard University), Ph.D. (University of Notre Dame), Associate Professor of Management

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BUSINESS ADMINISTRATION

The major objective of the undergraduate degree program in the College of Management Science is to provide a professional education for young men and women who have managerial aspirations and the ambition to prepare for them. (See the Graduate School Catalogue for information on the Master of Management Science program.)

The intent of the first two years is to permit the student to acquire a foundation in the basic arts and sciences and a competency in analytical processes. Students are also introduced to accounting, business law, economics, and electronic data processing at this time, subjects which provide the basis for the professional course work of the junior and senior years.

After completing the two year program described above, students select a major area of study from the fields of accounting, economics, and management. Students selecting the management option have the further opportunity of concentration in production, marketing, or financial management.

FRESHMAN YEAR

First Semester

BA	191	Physical Science I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
SS	303	Psychology	(3-0)3
SS		History or Government Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	192	Physical Science II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
SS	305	Sociology	(3-0)3
SS		History or Government Elective	(3-0)3
		Total hours	(15-0)15

All nonveteran male students who are physically qualified must take physical education two hours per week during the entire freshman year.

Students who elect to take the four-year AFROTC program must take the first two years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the junior and senior years may be substituted for other subjects. See the sections of the catalogue describing the individual curriculum, and the section on AFROTC for further details.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	362	Business Law	(3-0)3
EC	201	Economics I	(3-0)3
LL		English Elective*	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Total hours	(15-0)15

It is recommended that students take LL 207 Oral Business Communications, and LL 210 Technical and Scientific Communication. Students who plan to major in economics should take LL 311 Creative Writing and Advanced Composition. These courses can be taken either semester.

Second Semester

BA	142	Accounting II	(3-0)3
BA	403	Electronic Data Processing	(3-0)3
EC	202	Economics II	(3-0)3
EC	211	Economic Statistics I	(3-0)3
LL		Engish Elective	(3-0)3
		Total hours	(15-0)15

ACCOUNTING MAJORS

JUNIOR YEAR

First Semester

BA	241	Accounting III	(3-0)3
BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	242	Accounting IV	(3-0)3
BA	332	Money and Banking	(3-0)3
BA	344	Cost Accounting	(3-0)3
BA	453	Organizational Behavior	(3-0)3
EC	402	Government and Business	(3-0)3
		Total hours	(15-0)15

SENIOR YEAR

First Semester

BA	341	Accounting V	(3-0)3
BA		Accounting Elective	(3-0)3
EC	412	Managerial Economics	(3-0)3
		General Elective or R.O.T.C.	3
		Humanities Elective	(3-0)3
		Total credit hours	15

Second Semester

BA	498	Business Policy	(3-0)3
BA		Accounting Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	15

ECONOMICS MAJORS

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	332	Money and Banking	(3-0)3
BA	453	Organizational Behavior	(3-0)3
EC	304	Macroeconomic Theory	(3-0)3
EC	311	Mathematics for Economists	(3-0)3
EC	402	Government and Business	(3-0)3
		Total hours	(15-0)15

SENIOR YEAR

First Semester

EC	412	Managerial Economics	(3-0)3
EC		Economics Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	(15-0)15

Second Semester

BA	498	Business Policy	(3-0)3
EC		Economics Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	15

MANAGEMENT MAJORS

JUNIOR YEAR

First Semester

BA	321	Marketing Principles		(3-0)3
BA	331	Business Finance		(3-0)3
BA	372	Production Principles		(3-0)3
EC	212	Economic Statistics II		(3-0)3
		Humanities Elective		(3-0)3
			Total hours	(15-0)15

Second Semester

BA	346	Managerial Accounting		(3-0)3
BA	453	Organizational Behavior		(3-0)3
EC	402	Government and Business		(3-0)3
		Management Elective		(3-0)3
		General Elective		(3-0)3
			Total hours	(15-0)15

SENIOR YEAR

First Semester

EC	412	Managerial Economics		(3-0)3
		General Elective or R.O.T.C.		3
		Management Elective		(3-0)3
		Management Elective		(3-0)3
		General Elective		(3-0)3
			Total credit hours	(15-0)15

Second Semester

BA	498	Business Policy		(3-0)3
		General Elective or R.O.T.C.		3
		Management Elective		(3-0)3
		General Elective		(3-0)3
		Humanities Elective		(3-0)3
			Total credit hours	15

Notes on electives:

General elective: refers to any course given at the Institute. Courses given in other colleges of the Institute that duplicate courses taken by the student in the College of Management Science are not acceptable.

Humanities elective: refers to any course bearing an EC, LL or SS designation.

Management elective: refers to any course bearing a BA, EC, or IM designation. Courses in the behavioral science areas are acceptable with permission.

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide a student with a sound foundation in the pure sciences and mathematics, in the humanities, and in the social sciences. In addition, the core subjects of management — accounting, finance, marketing and production — are required. All students also take a selection of engineering and management courses to prepare them to handle the tasks they will have in industry after graduation. Some specialization is provided in the junior and senior years under guidance of a Faculty Advisor.

FRESHMAN YEAR

First Semester

EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	103	Calculus I	(3-0)3
PH	101	Physics	(4-1)4
		Total hours	(13-1)13

Second Semester

EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	104	Calculus II	(3-0)3
ME	104	Design Graphics	(1-0)1
PH	102	Physics	(4-2)4
		Total hours	(14-2)14

In addition to the preceding schedule all nonveteran male students who are physically qualified must take physical education two hours per week during the entire freshman year.

Students who elect to take the four-year AFROTC program must take the first two years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the junior and senior years may be substituted for other subjects. See the sections of the catalogue describing the individual curriculum, and the section on AFROTC for further details.

SOPHOMORE YEAR

First Semester

BA	143	Accounting Management I	(3-0)3
CH	101	Chemical Principles	(4-0)3
CH	103	Chemical Principles Laboratory	(0-2)1
MA	203	Calculus III	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
PH	201	Physics	(4-2)4
		Total hours	(15-7)16

Second Semester

BA	144	Accounting Management II	(3-0)3
CH	102	Chemical Principles	(4-0)3
CH	104	Chemical Principles Laboratory	(0-2)1
EC	211	Economic Statistics I	(3-0)3
LL	210	Technical & Scientific Communication	(3-0)3
MA	204	Calculus IV	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-3)3
BA	371	Production Principles	(3-0)3
EC	212	Economic Statistics II	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
		Total hours	(17-0)17

Second Semester

BA	403	Electronic Data Processing	(3-0)3
IM	372	Production Problems	(3-0)3
IM	483	Statistical Quality Control	(3-0)3
ME	372	Strength of Materials	(3-0)3
		General Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

BA	404	Computer Applications to Management	(3-0)3
BA	451	Personnel Management	(3-0)3
EE	351	Industrial Electronics	(3-0)3
MA	381	Operations Research	(3-0)3
		General Elective	3
		BA or EC Elective*	3
		Total credit hours	15

*ROTC students may elect AS 401.

Second Semester

EC	412	Managerial Economics	(3-0)3
MA	382	Operations Research	(3-0)3
ME	344	Heat and Power	(3-0)3
		General Elective	3
		BA or EC Elective*	3
		Total credit hours	15

*ROTC students may elect AS 402.

BUSINESS ADMINISTRATION

BA 141-142 Accounting I and II (3-0) (3-0)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 143-144 Accounting Management I and II (3-0) (3-0) 6
[I.M. Students Only]

These courses are designed to give the industrial management student an understanding of accounting concepts and techniques. Special emphasis on the role of cost accounting in the manufacturing process.

BA 191 Physical Science I (3-0)3

An introduction to the topics of physics and astronomy including: kinematics, dynamics, energy, heat, atoms and molecules, wave motion, electricity, magnetism and the solar system.

BA 192 Physical Science II (3-0)3

A survey of topics in modern physics, chemistry, and geology including: relativity, waves and particles, Bohr theory of the atom, periodic table, chemical bond, ions and solutions, chemical reactions, earth materials, and study of the atmosphere.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3

An analysis of the marketing of goods and services to final consumers and intermediate customers. The study of decision areas such as product planning, channels of distribution, promotion, and pricing is based upon a framework of consumer behavior, environmental forces, governmental constraints, and the existing structure of business institutions involved.

BA 324 Industrial Marketing (3-0)3
[BA 321]

Special problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing strategy. Cases will be used.

BA 325 Advertising (3-0)3
[BA 321]

Commencing on a foundation of the historical evolution of advertising and the economic and social role of promotion, this course takes in an in-depth look at advertisers, advertising agencies, and media as well as advertising creation and evaluation.

BA 326 Marketing Research (3-0)3
[BA 321, EC 211]

The process of planning, executing, and evaluating marketing research which is the information-gathering function of marketing management. Students work on individual research projects in the course.

BA 331 Business Finance (3-0)3
[BA 142, EC 201-202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 Money and Banking (3-0)3
[EC 202]

The evolution of money and credit and their role in the economy. Monetary policies of the Federal Reserve System. The structure and operation of the commercial banking system and the creation of money. The role of other financial institutions and their effect on the economy.

BA 334 Investment Management (3-0)3
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 Accounting V and VI (3-0) (3-0)6
[BA 242]

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshall accounting information for internal control and for service to management at all levels.

BA 344 Cost Accounting (3-0)3
[BA 142]

An examination of the manufacturing function from the view of the cost accountant. Managerial control of the elements of costs will be studied with an emphasis on job lot and process cost accounting systems.

BA 346 Managerial Accounting (3-0)3
[BA 142]
(For Non-accounting Majors)

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 Business Law (3-0)3

Principles of commercial law encompassing a study of contracts, agency, employment, commercial paper and sales including the Uniform Commercial Code.

BA 363 Advanced Business Law (3-0)3
[BA 362]

The analysis of the legal principles underlying real and personal property, corporations, partnerships, trusts and estates.

BA 371 Production Principles (3-0)3

Principles of manufacturing organization and productive processes with emphasis placed upon the functions of production systems; operational planning and control; plant layout; materials handling; inventory and quality control.

BA 372 Production Management (3-0)3
[BA 371]

A case course in the application of the principles covered in BA 371. The cases are representative of a wide range of products and industries. Small, medium and large manufacturing enterprises are studied; consideration is given to intermittent, continuous, and job lot systems of production.

BA 402 International Business (3-0)3
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's computer installation.

BA 404 Computer Applications to Management (3-0)3
[BA 403]

An investigation of the applications of electronic computers in the management of business enterprises. Attention is given to problems of management under conditions of uncertainty, inventory and production control, queuing theory, linear and nonlinear programming.

BA 421 Procurement (3-0)3
[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 422 Retailing (3-0)3
[BA 321]

The organization, operation, and management of retailing institutions. Students will compare and evaluate various types of firms and current developments in the field.

BA 423 Marketing Management (3-0)3
[BA 321 and BA 326]

Analyzes the process wherein the marketing strategies and plans of a competitive firm are formulated, implemented, and adjusted over time. Utilizes cases to study the behavioral, quantitave, and environmental aspects of marketing decision-making.

BA 426 Sales Management (3-0)3
[BA 321]

Analyzes the management of the personal selling function in its broadest aspects. Topics include sales force organization, selection, training, compensation, supervision, and motivation.

Cases are used to emphasize the application of general principles to actual management problems.

BA 431 Financial Management (3-0)3
[BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 432 Financial Institutions and Markets (3-0)3
[BA 331, 332]

This course covers the theoretical and pragmatic aspects of the financial process in our economic system. Financial intermediation as accomplished through institutions and markets is thoroughly analyzed.

BA 441 Auditing (3-0)3
[BA 242]

Auditing will be studied through the use of current professional literature and selected case studies. Current auditing standards, practices and problems are examined in detail. The course will stress conceptual understanding rather than procedural problem solving.

BA 442 Advanced Public Accounting (3-0)3
[BA 441]

An examination of the controversial areas of public accounting with special attention on the professional and technical aspects of practice. The course will include a study of systems and procedures engagements, auditing data procession, S.E.C. audits, and management services.

BA 444 Advanced Cost Accounting (3-0)3
[BA 344]

Topics covered will include standard (estimated) costs, variance analysis, profit planning, cost-volume-profit analysis, and relevant cost analysis for problem solving.

BA 445 Federal Income Taxes (3-0)3
[BA 142]

This course deals with the basic rules and regulations of the Internal Revenue Code as it affects the individual and the corporation. An understanding of the code is developed through lectures, assigned readings, research, and the solution of a wide variety of problems.

BA 448 Seminar in Accounting (3-0)3
[For Accounting Seniors Only]

Readings on contemporary accounting problems, controversies in current accounting practice and computer utilization in accounting systems comprise the foundation of the seminar. Extensive use is made of cases to illustrate problem areas in current accounting practice. Written and oral defense of case conclusions are important aspects of the course.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 Industrial Relations (3-0)3
[BA 451 or 453]

Human interaction and group behavior in organized industrial settings; union-management relations; grievance procedures and arbitration; job evaluation; motivation and leadership.

BA 453 Organizational Behavior (3-0)3

Basic findings and concepts of the behavioral sciences will be related to the specific aspects of behavior in organizations. Individual and group behavior will be examined. The process of improving and achieving change in organizations using behavioral concepts will be explored.

BA 471 Analytical Methods in Management (3-0)3
[BA 321, BA 331, BA 371]

A survey of the quantitative techniques available to assist management in the decision making process. Applications in the functional areas of marketing, production, and finance will be explored.

BA 472 Management of Organizations (3-0)3
[BA 451 or 453]

The course treats managing and organizations as interrelated dynamic decision processes and systems. It is concerned with values, communications, interactions, as well as with resources, environment and people. Varying organizational structures and their content are examined, including those in the public, voluntary, and business fields.

BA 481 **Insurance** **(3-0)3**

Principles of risk and risk management. Emphasis on life, health, fire, and casualty insurance as methods of handling risks.

BA 492 **Physical Distribution Management** **(3-0)3**

Emphasis on the analytical needs involved in the management of the functions that comprise physical distribution: warehousing, inventory control, materials handling, and industrial packaging. Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies in the United States.

BA 498 **Business Policy** **(3-0)3**
[Seniors in BA and IM only]

A study of the functions and responsibilities of general management and their interrelationships. Consideration will be given to the problems which affect the character and success of the total enterprise. Emphasis will be placed on corporate strategy the setting of objectives, establishing policies, and structuring the enterprise.

BA 499 **Research Seminar** **3**
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

ECONOMICS

EC 201 **Economics I** **(3-0)3**
A study of the principles governing the production and exchange of goods and services.

EC 202 **Economics II** **(3-0)3**

A study of the principles governing the level of national income and employment. Examination of the commercial banking system, monetary and fiscal policy, the international economy, and alternative economic systems.

EC 211 Economic Statistics I (3-0)3

Descriptive statistics, sophisticated counting techniques and other components of probability, simple random variables and their distributions, bivariate functions, sampling theory, properties of estimators, maximum likelihood estimation, confidence intervals, and hypothesis testing.

EC 212 Economic Statistics II (3-0)3
[EC 211]

Analysis of variance, regression theory, multiple regression, correlation, and decision theory.

EC 302 Labor Economics (3-0)3
[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 Microeconomic Theory (3-0)3
[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 Macroeconomic Theory (3-0)3
[EC 202]

An analysis of Keynesian and Post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 305 Regional Economics (3-0)3
[EC 202]

An introductory approach and survey of theories of location of firms, industries and population. Regional income accounting systems and intra/interregional income models.

EC 306 Urban Economics (3-0)3
[EC 202]

An introduction to urban economics. Analysis of intra-metropolitan spatial relationships including residential location and land and housing markets.

EC 307 Economic Analysis of Urban Problems (3-0)3
[EC 202]

Analysis of the economic structure of urban areas. The tools of economic analysis are applied to urban problems such as poverty, transportation, education, pollution and the financing of urban government.

EC 311 Mathematics for Economists (3-0)3
[MA 201, EC 303]

Mathematical background for the study of econometrics. Study of sets, functions, and limits; differentiation; integration; series; differential equations; vectors and matrices.

EC 401 Current Problems (3-0)3
[EC 303, BA 332, EC 402]

A seminar on selected problems which confront the contemporary American economy.

EC 402 Government and Business (3-0)3
[EC 202, BA 332]

An examination of the various governmental controls over business in the American economy. Emphasis on court interpretations of the antitrust laws and on the economic theory and political philosphy behind them.

EC 403 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 Comparative Economic Systems (3-0)3
[EC 303, BA 332]

Analysis of free-market and planned economies in theory and practice. Emphasis on the United States and the Soviet Union.

EC 405 Marxism and the Soviet Economy (3-0)3

The economic system of Marx: dialectic materialism and Marx's economic model of capitalism. The contemporary Soviet example is considered with an emphasis on the economic planning process and the current system of incentives and success indicators.

EC 406 Welfare Economics (3-0)3
[EC 303]

An evaluation of Pareto Optimality and the Hicks-Kaldo

Compensation Principle. Divergence from the purely competitive norm and the Theory of the Second Best. Discussion of the Arrow Impossibility Theorem.

EC 407 Econometrics (3-0)3
[EC 212, 304]

The course will provide the student both theoretical and empirical knowledge of econometrics. Methods of handling data, quantitative empirical estimates, and tests of economic theory.

EC 408 History of Economic Thought (3-0)3
[EC 303]

The rise of classical growth and value theories. The evolution of neoclassical theories of price and distribution, and the development of welfare criteria. A comparison of Keynesian and classical macroeconomic theory. The role of economic analysis in the post-Keynesian world.

EC 409 Growth Theory (3-0)3
[EC 304, EC 311, BA 332]

Analysis of cyclical fluctuations and long-term economic growth. Construction of economic growth models.

EC 410 Economic Development of Less Developed Countries (3-0)3
[EC 202]

The role of capital (private and social), technology, labor, governments, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 Public Finance (3-0)3
[EC 303, 304]

The economics of the public sector. Principles of public expenditure, taxation, and the public debt applied to federal, state, and local governments.

EC 412 Managerial Economics (3-0)3
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 414 **Engineering Economy** **(3-0)3**
[EC 202]
[Not for BA or IM students]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

EC 499 **Research Seminar** **(3-0)3**
[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.

INDUSTRIAL MANAGEMENT

IM 371 **Operations Research** **(3-0)3**

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 372 **Production Problems** **(3-0)3**
[BA 371]

A quantitatively oriented case course stressing the functional interrelationship of major manufacturing decisions facing management. Emphasis will be placed on problems of operations management, including scheduling, inventory control and facilities design, and methods of implementation, applied theory of mathematical programming, simulation, statistical models and organizations design.

IM 483 **Statistical Quality Control** **(3-0)3**
[MA 383 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 499 **Research Seminar** **3**
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

COLLEGE
OF
PURE AND APPLIED SCIENCES

COLLEGE OF PURE AND APPLIED SCIENCES

Leon E. Beghian, Acting Dean and Provost

The College of Pure and Applied Science offers programs which enable the student to acquire a broad preparation for life in a technological society, to obtain a sound basis for his professional education, and to receive training in specific skills required for service in his chosen field of endeavor.

The courses offered in the College provide the student with an opportunity to understand the problems of the past and the solutions thereof achieved, to understand the present state of knowledge, and to develop habits of analytical thought and mental discipline necessary for the definition and solution of present and future problems.

Students intending to terminate their formal education at the bachelor level will find that they are prepared for a broad spectrum of technical positions in industry and government, while those who intend to go on to higher degrees will find that they have been well prepared for further study in graduate and professional schools.

Generally speaking, only those students who have had a definite interest in and proficiency in high school science and mathematics should enter study in the College.

The student may enroll in any one of the following curricula:

- Biological Sciences
- Chemistry
- Mathematics
- Meteorology
- Nuclear Engineering (in Physics and Applied Physics)
- Physics and Applied Physics
- Radiological Health Physics

Students desiring to enroll in one of these curricula should consult with the department involved.

Department of Biological Sciences

Robert M. Coleman, B.S. (Bates College), M. S. (University of New Hampshire), Ph.D. (University of Notre Dame), Professor and Chairman

Sydney S. Biechler, B.S. (Stanford University), Ph.D. (Pennsylvania State University), Professor

Timothy Macdonald, B.A., Ph.D. (University of Hawaii), Assistant Professor

John C. Mallett, B.S. (College of the Holy Cross), M.S., Ph.D. (University of Rhode Island), Instructor

Patricia G. Mulhall, B.S. (Utica College of Syracuse University), M.S. (Rensselaer Polytechnic Institute), Assistant Professor

Nicholas G. Rencricca, B.S. (St. Francis College), M.S. (St. John's University), Ph.D. (Boston College), Assistant Professor

BIOLOGICAL SCIENCES PROGRAM

The Department was established in the fall of 1968 and is presently housed in temporary quarters which have been substantially increased. New facilities are expected to be completed for occupancy during the 1972-73 academic year. An area of 30,000 sq. ft. has been designed to include teaching laboratories, undergraduate research facilities, office-research modules and service areas such as animal quarters, rooms for instrumentation, preparation and temperature control as well as X-ray, electron microscope and greenhouse facilities.

The curriculum in the Biological Sciences is designed to provide a sequence of liberal arts and science courses for a sound career foundation. Development of attitudes along with abilities is considered highly significant for a successful career. The importance of a breadth of knowledge and understanding of related scientific disciplines is stressed for greater appreciation and comprehension of biological principles and modern quantitative concepts.

Upon graduation the biology major will find opportunities in teaching, industry, government and the medical services. The curriculum objectives chosen permit a sound preparation for graduate study in the biological sciences, medicine and dentistry.

A written comprehensive examination is required of all majors. Students who have demonstrated high scholastic ability may conduct independent studies throughout the senior year. Emphasis is placed on completion of an original research project followed by an oral examination of the candidate's major courses and undergraduate thesis.

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology		(3-3)4
CH	221	Organic Chemistry		(3-4)4
MA	203	Calculus III		(3-0)3
PH	201	Physics		(4-2)4
			Total hours	(13-9)15

Second Semester

BI	202	Principles of Biology		(3-3)4
CH	222	Organic Chemistry		(3-4)4
MA	383	Statistical Methods		(3-0)3
		Two General Electives*		(6-0)6
			Total hours	(15-7)17
*LL	334	Problems of Philosophy and		
SS	304	Psychology are recommended		

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
BI	331	Ecology	(3-3)4
CH	335	Principles of Physical Chemistry	(3-3)4
		Technical Elective	4
		Total hours	16

Second Semester

BI	306	Biochemistry	(3-3)4
BI	312	Microbiology	(3-3)4
CH	336	Principles of Physical Chemistry	(3-3)4
		Technical Elective	4
		Total credit hours	16

SENIOR YEAR

First Semester

BI	411	Research in Biology or Biology Elective	4
BI	451	Seminar in Biology	(1½-0)1
RS	441	Radioisotope Techniques	(3-3)4
		General Elective	(3-0)3
		Technical Elective or General Elective	3
		Total credit hours	15

Second Semester

BI	412	Research in Biology or Biology Elective	4
BI	452	Seminar in Biology	(1½-0)1
BI	462	Radiation Biology	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective or General Elective	3
		Total credit hours	17

Not more than a total of six credits of junior or senior AS subjects may be substituted for technical or general electives.

BIOLOGICAL SCIENCES COURSE DESCRIPTIONS

BI 201 **Principles of Biology** **(3-3)4**
[CH 102, CH 104]

Part one of a basic course which includes an introduction to cell structure, cellular metabolism, molecular genetics, protein synthesis, bacteria and viruses, and systems of the human body.

BI 202 **Principles of Biology** **(3-3)4**
[BI 201]

Part two of a basic course dealing with the structure, function, and diversity of living organisms including a brief survey of the animal and plant kingdoms, photosynthesis, developmental biology, population genetics, ecology and evolution.

BI 301 **Physiology** **(3-3)4**
[BI 202]

Structural, chemical and physical aspects of important processes in mammals. Mechanims operative at the molecular, cellular, and organismic levels related to (1) intake, transport, metabolism and excretion of gases and nutrients, (2) immune protection, (3) muscle contraction and (4) integrative activity of the nervous and endocrine systems.

BI 306 **Biochemistry** **(3-3)4**
[CH 222 or 224, CH 232 or 336 concurrently]

Fundamental concepts in biochemistry including protein structure and biosynthesis; enzyme structures and mechanisms; nucleic acids and genetic development, metabolism; photosynthesis, cellular structure; functions and structure of carbohydrates, hormones, lipids, and hemins; chemical functions of organs.

BI 312 **Microbiology** **(3-3)4**
[BI 202]

A study of the morphology and the chemical and physical activities of representative bacteria, yeasts, molds, viruses and animal parasites as related to man. The laboratory covers basic qualitative and quantitative techniques of microbiology with an introduction to selected immunochemical methods.

BI 331 **Ecology** **(3-3)4**
[BI 202]

A course dealing with factors responsible for the relationships of living organisms to each other and to their natural environment. The nature and dynamics of the biotic community.

BI 332 **Botany** **(3-3)4**

An introduction to the plant kingdom dealing with the structure, function, and diversity of the different plant forms. The cytology, ecology, morphology, physiology, and taxonomy of plants will be considered.

BI 371 **Genetics** **(3-3)4**
[BI 202]

The laws of biological inheritance. The molecular basis of heredity is stressed. Replication of DNA, genetic codes and fine structures of chromosomes are considered.

BI 411-412 **Research in Biology** **(0-12) (0-12)8**

An individual, directed research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration is required.

BI 421 **The Environmental Biology of Man** **(3-0)3**

This course will be centered on Man as a biological entity. His chemistry, cellular design, and physiology will be described as well as his requirements for growth, repair, and reproduction. The extent to which he depends on other organisms and on chemicals in his environment to meet these requirements will be outlined. Specific examples will be cited to show direct or indirect imbalances in nature on Man's ability to meet his requirements. The importance of species interaction and their dependence on the physical environment will be emphasized. Not open to Biology majors.

BI 451-452 **Seminar in Biology** **(1½-0) (1½-0)2**

Seminar discussion of selected topics of current research interest. Offered each semester by a different member in his special discipline. Student participation in the form of discussion and presentation of papers. For senior biology majors.

BI 456 **Endocrinology** **(3-3)4**
[BI 301] [Offered in alternate years]

Structure and physiology of the endocrine glands. Emphasis will be given to the synthesis, transport, and mechanism of hormone action with regard to regulation of intermediary metabolism and maintenance of an homeostatic microenvironment. Endocrine imbalances, resulting in disease will also be discussed.

BI 462 **Radiation Biology** **(3-3)3**
[BI 202, RS 441]

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and late effects in whole animals and the modification of radiation exposure by physical, chemical and biological factors.

BI 481 **Immunobiology** **(3-3)4**
[BI 311] [Offered in alternate years]

This course deals with the biology of the immune response with sections on antibody production, reaction with antigen, suppression, tolerance, protection and injury.

BI 506 **Ecological Physiology** **(3-3)4**
[BI 301, BI 330]

A consideration of physiological, evolutionary and environmental aspects of interactions between organism and environment with special emphasis on homeostatic adaptations to biotic and abiotic environmental fluctuations.

BI 513 **Enzymology** **(3-0)3**
[BI 306]

The structure, properties, modes of activation, and mechanisms of action of some specific enzymes will be discussed, as well as general and specific methods for isolation, characterization and study. Enzyme kinetics, induction and repression, and isoenzyme systems will also be covered with emphasis on current findings.

BI 561 **Electron Microscopy** **(2-3)3**
[Permission of Instructor]

An introduction to the theory and operation of the transmission and scanning electron microscopes. Preparation of biological specimens for EM viewing and photography will be stressed. Applications in biology will be discussed.

Department of Chemistry

Philip S. Lamprey, B.S. (Lowell Technological Institute), Ph.D. (University of New Hampshire, Professor and Head

William W. Bannister, B.S., Ph.D. (Purdue University), Associate Professor

Eugene F. Barry, Jr., B.S. (Villanova College), Ph.D. (University of Rhode Island), Instructor

Alexandre Blumstein, B.S. (Sorbonne), Ph.D. (Strasbourg University), Professor

Barbara L. Brooks, B.S. (Lowell Technological Institute), Instructor

Stuart B. Clough, B.S. (University of Massachusetts), M.Ch.E. (University of Delaware), Ph.D. (University of Massachusetts), Assistant Professor

Charles L. Daley, B.T.C. (Lowell Technological Institute), Professor

George R. Griffin, B.S. (Indiana University), M.A. (Boston University), Ph.D. (Massachusetts Institute of Technology), Professor

Judith A. Horine, B.A. (Rivier College), Assistant Professor

Martin Isaks, B. S. (Purdue University), M.S. (Iowa State University), Ph.D. (University of Cincinnati), Associate Professor

Stanley C. Israel, B.S. (Parsons College), Ph.D. (Lowell Technological Institute), Assistant Professor.

Ernest P. James, B.T.C., M.S. (Lowell Technological Institute), Professor

Albert D. Kowalak, B.S. (College of William and Mary), M.S., Ph.D. (Virginia Polytechnic Institute), Associate Professor

Vasilis Lavrakas, B.S. (University of Massachusetts), M.S. (Tufts University), Professor

Irving Lipschitz, B.A., M.S. (New York University), Ph.D. (Virginia Polytechnic Institute), Assistant Professor

Robert J. Peirent, B.S., M.S. (Lowell Technological Institute), Professor

James B. Pierce, B.S. (Thiel College), M.S., Ph.D. (Case Institute of Technology), Professor

Chong Wa Pyun, B.S., M.S. (Seoul National University), Ph.D. (Brown University), Associate Professor

Harry Rubinstein, B.S. (Brooklyn College), Ph.D. (Purdue University), Professor

Joseph C. Salamone, B.Sc. (Hofstra University), Ph.D. (Polytechnic Institute of Brooklyn), Assistant Professor

Allen Scattergood, A.B. (Columbia University), Ph.D. (Princeton University), Professor

Sami A. Shama, B.Sc (Cairo University), M.S. (Lowell Technological Institute), Instructor

Judith A. Tilden, B.A. (Emmanuel College), Instructor

Arthur C. Waterson, Jr., B.S. (Geneva College), Ph.D. (Brown University), Professor

Charles R. Wilson, B.S. (Lowell Technological Institute), Instructor

CHEMISTRY PROGRAM

The curriculum is Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. In includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

SOPHOMORE YEAR

First Semester

CH	207	Inorganic Chemistry	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
PH	201	Physics	(4-2)4
		Total hours	(15-9)17

Second Semester

CH	210	Analytical Chemistry I	(3-4)4
CH	222	Organic Chemistry	(3-4)4
CH	232	Physical Chemistry	(3-3)4
MA	204	Calculus IV	(3-0)3
		Total hours	(12-11)15

JUNIOR YEAR

First Semester

CH	311	Analytical Chemistry II	(3-4)4
CH	333	Physical Chemistry	(3-3)4
LL	261	Elementary Technical German	(3-0)3
		Two General Electives	(6-0)6
		Total hours	(15-7)17

Second Semester

CH	442	Advanced Inorganic Chemistry I	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		Chemistry Elective	3 or 4
		Two General Electives	(6-0)6
		Total credit hours	15 or 16

SENIOR YEAR

First Semester

Chemistry Elective	3 or 4
One Technical Elective	3
Two General Electives	6
One Technical or General Elective	3
Total credit hours	15 or 16

Second Semester

Chemistry Elective	3 or 4
One Technical Elective	3
Two General Electives	6
One Technical or General Elective	3
Total credit hours	15 or 16

The Technical Electives in the Junior and Senior years must include chemistry subjects which will provide a minimum of 60 contact hours of laboratory instruction. Recommended laborato-

ry electives include CH 321, CH 342, CH 403 and 404, CH 407 and 408 and CH 481 and 482. If Undergraduate Thesis is elected, both semesters must be taken, and one additional laboratory subject must also be taken to provide an approved program.

The General Electives in the Junior and Senior years must include a minimum of 18 credits in Humanities and Social Studies not including elementary foreign language, composition, or communication subjects.

A student electing Air Force ROTC in the Junior and Senior years may substitute a maximum of six credits of required General or Technical Electives by AS subjects. It is recommended that this substitution be made in the Senior year.

CHEMISTRY COURSE DESCRIPTIONS

CH 101 — Chemical Principles — (4-0)3

Basic concepts of Chemistry including nomenclature, stoichiometry, energy of reactions, oxidation-reduction, electrochemistry, kinetics, equilibrium, acids and bases, and fundamentals of atomic theory.

CH 202 — Chemical Principles — (4-0)3
[CH 101]

Basic chemical concepts including the modern approach to atomic structure, chemical bonding, determination of structure, nuclear chemistry, kinetic theory, solid, liquids, solutions, chemistry of metals and non-metals, and organic and biochemistry.

CH 103 — Chemical Principles Laboratory — (0-2)1

An experimental study of chemical principles and chemical transformations. Reactions of some important elements and compounds are examined and related to the periodic table. Considerable emphasis is placed on acquainting students with techniques, methods and instruments essential to quantitative chemical measurements. Topics include methods of chemical separation, reactions, organic synthesis, formula determination and absorption spectroscopy.

CH 104 — Chemical Principles Laboratory — (0-2)1
[CH 103]

A continuation of the experimentation of CH 103 including determinations of molar volume, molecular weight, reaction

rate, heat of reaction, redox potential and pH. Analytical chemistry is introduced with acid-base and oxidation reduction titrations. Careful observation and logical deduction techniques are encouraged.

CH 207 Inorganic Chemistry (3-3)4
[CH 102]

The chemical behavior, structures, methods of preparation, and nomenclature of the more important elements and their compounds. The laboratory illustrates basic principles used in the preparation and study of inorganic compounds.

CH 210 Analytical Chemistry I (3-4)4

This course will focus on the evaluation of analytical data, aqueous and non-aqueous acid-base systems; oxidation-reduction and complexation equilibria; solubility and precipitation, solvent extraction, ion-exchange and chromatographic methods. In the laboratory the student will perform experiments in gravimetric and volumetric methods of analysis.

CH 221 Organic Chemistry (3-4)4

Kernel-electronic formulation, nomenclature and mechanism of reaction of the following classes of chemical species: monatomic, diatomic, multiatomic molecules and ions, alkanes, alkenes, alkynes, other non-aromatic hydrocarbons, alkyl halides, organometallics, alkanols, alkyl esters of inorganic acids, dialkyl ethers, alkanoic acids and derivatives. The laboratory work consists of practice in planning and carrying out reactions to form products isolable by distillation.

CH 222 Organic Chemistry (3-4)4
[CH 221]

Formulation, nomenclature, mechanism of reaction, and overall equations for property reactions of the following classes of compounds: aldehydes; ketones; amines; organosulfurs; carbonic acid derivatives; multihydroxyaldehydes and derivatives including stereochemistry; carbohydrates; arenes; aryl halides; arenesulfonic acids; nitroarenes; arylamines; phenols; quinones; aromatic aldehydes, ketones, alcohols and carboxylic acids; multicyclic aromatic hydrocarbons and derivatives; heterocyclics and alkaloids. The laboratory work consists of instruction and practice in planning and successfully carrying out reactions to form solid products isolable by crystallization.

CH 223 Introductory Organic Chemistry I (3-0)3
[Primarily for students not majoring in Chemistry]

Lectures in this course will include discussions of structures (with emphasis on molecular orbital theory and stereochemistry), classification by functionality, nomenclature, syntheses, and reactions and reaction mechanisms of organic compounds.

CH 224 Introductory Organic Chemistry II (3-0)3
[CH 223]

A continuation of the first semester subject (CH 223).

CH 225 Introductory Organic Chemistry Laboratory I (0-4)1

Laboratory work in this course is scheduled to accompany topic presentations in the lecture phase of the course (CH 223), and will be devoted to product separation and purification techniques, and methods of synthesis of industrially important organic compounds.

CH 226 Introductory Organic Chemistry Laboratory II (0-4)1
[CH 225]

A continuation of the first semester lab course (CH 225).

CH 232 Physical Chemistry (3-3)4
[MA 203]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 311 Analytical Chemistry II (3-4)4

The course will introduce the student to the modern instrumental methods of chemical analysis. The following techniques will be discussed: flame photometry; emission, atomic absorption, ultraviolet, infrared and nuclear magnetic resonance spectroscopy; potentiometry, electrolysis, coulometry, polarography, and amperometry; thermogravimetric and differential thermal analysis. Experiments emphasizing these techniques will be conducted by the student in the laboratory.

CH 321 Organic Chemistry Laboratory II (1-6)3
[CH 222]

A continuation of CH 222 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 333 **Physical Chemistry** **(3-3)4**
[CH 232]

Introduction to principles of statistical mechanics, kinetics, electrochemistry, and atomic and molecular structure.

CH 335 **Principles of Physical Chemistry** **(3-3)4**
[MA 203]

Similar to CH 232 and 333 but designed for students not majoring in Chemistry.

CH 336 **Principles of Physical Chemistry** **(3-3)4**
[CH 335]

A continuation of CH 335.

CH 342 **Organic Qualitative Analysis** **(1-6)3**
[CH 222]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403 **Introductory Physical Chemistry of Macromolecules** **(3-0)3**
[CH 222 or 224, CH 333 or 336]

An introduction to the physical chemistry of polymers, including molecular weight distributions and averages, polymer solutions, fractionation, methods of molecular weight determination, and structure and properties in the rubbery, glassy, and crystalline states.

CH 404 **Introductory Organic Chemistry of Macromolecules** **(3-0)3**
[CH 222 or 224, CH 333 or 336]

The organic chemistry of monomers and polymers including condensation and addition polymerization, copolymerization, mechanism of ionic and free radical polymerization, preparation of monomers and stereospecific polymers, naturally occurring and industrially important polymers.

CH 405 **Polymer Laboratory I** **(0-4)1**
[CH 222 or 224, CH 333 or 336]

An introductory laboratory in polymer science concerned with the characterization of polymers by solubility, viscosity and heat of polymerization, the kinetics of condensation polymerization, and the preparations of various polymers by means of the techniques of low temperature condensation, suspension and

emulsion polymerization, the purification of polymers and the preparation of foams and inorganic polymers.

CH 406 Polymer Laboratory II (0-4)1
[CH 222 or 224, CH 333 or 336]

An introductory laboratory in polymer science concerned with the preparations of resins and elastomers, polymerization by anionic initiation and oxidative coupling, fractionation of polymers, kinetics of addition polymerization, chain transfer, copolymerization and reactivity ratios, thermogravimetric analysis and differential thermal analysis.

CH 407 Undergraduate Thesis (0-9)3
[Permission of Department Head and Instructor]

Open only to Seniors majoring in chemistry. Research in analytical, organic, inorganic, physical, and polymer chemistry.

CH 408 Undergraduate Thesis (0-9)3

A continuation of CH 407. Both semesters must be taken and not more than six credits may be used in meeting degree requirements. Letter grades are given in both semesters. A written thesis is required following the conventional form of introduction, literature survey, results and conclusions. One copy of the thesis must be filed with the department office.

CH 409 History of Chemistry (1-0)1

A seminar course devoted to the discussion of the historical development of chemical principles. Each student is required to present to the class a paper for discussion.

CH 413 Nuclear Magnetic Resonance and Electron Spin Resonance Spectroscopy (3-0)3
[CH 432]

An introduction to the essentials of nuclear and electron spin resonance is presented to illustrate the scope and application of the method. May be taken for graduate credit.

CH 423 Advanced Organic Chemistry (3-0)3
[CH 222]

Extension of introductory organic chemistry for chemistry majors. Organic compounds and reactions are discussed in terms of reaction mechanisms, structure-reactivity and stereochemistry.

CH 424 Advanced Organic Chemistry (3-0)3
[CH 222]

Synthesis of organic molecules. Selected reagents and techniques are discussed with emphasis on the scope and limitations

of these reactions. The reaction mechanisms are also discussed.

CH 431 Advanced Physical Chemistry I (3-0)3
[CH 333 or equivalent]

Extension of introductory physical chemistry. Open to seniors and first year graduate students in chemistry and related fields. In the first semester, emphasis is placed on quantum chemistry of atoms and molecules.

CH 432 Advanced Physical Chemistry II (3-0)3
[CH 431 or equivalent]

Continuation of CH 431, with emphasis on classical and statistical thermodynamics of systems of chemical interest.

CH 434 Colloid and Surface Chemistry (3-0)3
[CH 232 or CH 335]

Theory of colloidal systems including physical chemistry of surfaces, electrokinetic phenomena and molecular kinetic and optical properties of colloids. Consideration is also given to thin layers and to foams and emulsions including the preparation of lyophobic colloidal systems, and the stability of lyophobic sols.

CH 442 Advanced Inorganic Chemistry I (3-0)3
[CH 333]

A theoretical treatment of the structure of the atom and inorganic compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics, theories of the chemical bond, crystal field theory, ligand field theory, and inorganic stereochemistry.

CH 445 Advanced Inorganic Chemistry II (3-0)3

A continuation of CH 442 with emphasis on the dynamics of inorganic systems. Topics include reactions in aqueous solvents, thermodynamics of coordination compounds and kinetics of fast reactions including stopped flow and temperature jump techniques.

CH 481 Radiochemistry (2-3)3
[CH 102, MA 204, PH 202]

An introduction to the fundamentals of radioactivity and radiochemistry. The laboratory work is directed to the detection and measurement of radioactivity. Designed primarily for majors in chemistry and allied fields.

CH 482 **Radiochemistry** **(2-3)3**

[CH 481]

A continuation of CH 481 with emphasis on the applications of chemical and nuclear principles and practices toward the preparation and separation of radionuclides. The laboratory experiments use such well-known techniques of separation as solvent extraction, ion-exchange, precipitation, coprecipitation and electrochemical displacement.

CH 484 **Elements of Radiochemistry** **(2-3)3**

Chemical principles are reviewed and their applications to radiochemistry are discussed. Such topics as separation procedures and chemical identification of nuclides, radiation chemistry, and study of fission products are included in the course.

CH 502 **Color Science** **(2-3)3**

An analytical course of the concepts and methods of absorption and reflectance spectrophotometry, and color measurement. Encompasses both theoretical and applied methods for determining qualitative and quantitative composition of colored substances in transparent and opaque materials such as liquids, paper, plastics, textiles, etc. Quantitative measurement of color, color difference, color matching and formulation by instrumental means based on the CIE and other trichromatic coordinate systems are studied. Computer usage and computer program developing problems are employed.

CH 513 **Spectroscopy** **(3-0)3**

[CH 431 and 432]

A presentation of molecular spectra and molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results.

CH 514 **Advanced Analytical Chemistry** **(3-0)3**

[CH 431 or equivalent]

An emphasis is placed on the determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions.

CH 515 **Chemical Literature** **(1-0)1**

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding, assembling and using such data.

CH 516 Advanced Laboratory Technique (1-3)2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 517 Glass Working (1-1)1

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 519 Environmental Chemistry (3-0)3
[CH 311 or equivalent]

A study of the reactions involving atmospheric and aquatic pollutants. Included are such topics as the oxides of nitrogen, carbon, and sulfur, particulate matter in air, and equilibria occurring in natural waters. Approved "wet" and instrumental methods of analysis for pollutants of current interest are also presented.

CH 521 Physical Organic Chemistry (3-0)3

Modern and Classical Methodology in the study of organic reactions. Fast reactions, linear free energy relationships, tracer methods, instrumental techniques and other selected topics will be covered.

CH 522 Physical Organic Chemistry (3-0)3
[CH 424]

This is a course in theoretical organic chemistry. General topical coverage includes polarization effects, intermolecular forces including hydrogen bonding, reactivity indices, transition state theory and activation parameters, electronically excited organic molecules, isotope effects, stereoselection in elementary organic reactions, and selected special topics.

CH 523 Organic Reaction Mechanisms and Structures (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 — Organic Synthesis — (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate sttudents only.

CH 531 — Statistical Thermodynamics — (3-0)3

[CH 432 or equivalent]

Fundamentals of equilibrium statistical mechanics; classical and quantum statistics. Molecular theories of gases, crystals, and liquids, with emphasis on chemical aspects. Electrolyte and non-electrolyte solutions, polymer and polyelectrolyte systems, chemical equilibria and reaction rate processes. Also, introduction to nonequilibrium statistical theories.

CH 534 — Quantum Chemistry — (3-0)3

[CH 431 or equivalent]

Principles and methods of quantum mechanics with special attention to chemical applications, such as electronic structure of atoms and molecules, vibration and rotation of molecules, and interaction of radiation with matter.

CH 535 — Advanced Topics in Physical Chemistry — (3-0)3

[Permission of instructor]

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 536 — Advanced Topics in Physical Chemistry — (3-0)3

[Permission of instructor]

Same as CH 535, with different topics.

CH 540 — Chemical Kinetics — (3-0)3

[CH 443 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 543 Modern Inorganic Chemistry I (3-0)3
[CH 333 or equivalent]

Similar to CH 443 but designed specifically for graduate students. Emphasis is placed on the theoretical-physical concepts of importance to inorganic chemists.

CH 544 Modern Inorganic Chemistry II (3-0)3
[CH 543]

A continuation of CH 543 with emphasis on the mechanisms of inorganic reactions.

CH 561 Advanced Organic Synthesis (3-0)3
[CH 523 and 524, or equivalent]

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids, antibiotics. Theoretical implications of organic reactions are also discussed.

Offered in alternate years.

CH 563 Chemistry of Natural Products (3-0)3
[CH 568, CH 311 or equivalent]

This course will cover the proof of structure of various types of natural products, approaches to the total synthesis of same and also the biosynthetic pathways.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy.

POLYMER SCIENCE

PS 503 Advanced Polymer Science I (3-0)3
[Permission of Instructor]

Introduction to chain statistics and thermodynamics of macromolecular solutions, methods of study of molecular weight and chain conformations, and the properties of polymers in bulk including viscoelasticity and crystallinity.

PS 504 Advanced Polymer Science II (3-0)3
[Permission of Instructor]

A study of the principles of condensation, free radical, ionic, coordination and ring-opening polymerization. The topics include the concepts of step-growth and chain-growth polymerization, the effect of polymerization technique on reaction kinetics and molecular weight and molecular weight distribution, and the evaluation of reactivity ratios in copolymerization reactions.

PS 505 Polymer Preparation and Characterization I (0-4)1
[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the techniques used in the syntheses and characterization of macromolecules.

PS 506 Polymer Preparation and Characterization II (0-4)1
[Permission of Instructor]

An advanced laboratory in polymer science concerned with the instrumental study of macromolecules by utilization of osmometry, light scattering, gel permeation chromatography, vapor pressure osmometry, infrared spectroscopy, thermogravimetric analysis and differential thermal analysis.

PS 511 Biopolymers (2-0)2
[Permission of Instructor]

Conformation and configuration of vinyl polymers and polypeptides. Helix-coil transitions in proteins and polypeptides. Biological specificity and macromolecular structure. Synthesis of stereoregular polypeptides. Structure and physical properties of nucleic acids. Relations of synthetic polymers to naturally occurring polymers.

PS 512 Bulk Properties of Polymers (2-0)2

[Permission of Instructor]

Structure and properties of bulk polymers in the glassy, rubbery, and crystalline states. Topics covered include chain statistics, rubber elasticity, glass transition, segmental motion and viscoelasticity.

PS 549 Physical Chemistry of Macromolecules I (2-0)2

[CH 503 or equivalent]

Physical chemistry of polymers, including structure and conformation, chain statistics, molecular weight distributions and averages, polymerization kinetics and classical and statistical thermodynamics of polymer solutions.

PS 550 Physical Chemistry of Macromolecules II (2-0)2

[CH 549 or equivalent]

Optical and hydrodynamic properties of polymer solutions. Methods of determination of structural parameters, including light scattering, viscometry, and other techniques.

PS 553 Organic Chemistry of Macromolecules (2-0)2

[PS 503, 504]

An advanced study in polymer science concerned with the syntheses of macromolecules and their mechanisms of formation.

Department of Mathematics

I. Jacob Weinberg, B.S. (Yeshiva University), S.M., Ph.D. (Massachusetts Institute of Technology), Professor and Chairman

Donald L. Ameen, B.S. (Lowell Technological Institute), M.S. (Cornell University), Assistant Professor

Edward F. Baldyga, B.A., M.A. (University of Connecticut), Instructor

Maurice Beren, B.S. (Massachusetts Institute of Technology), Instructor

Stephen J. Bodor, B.S., M.S. (Lowell Technological Institute), Professor

Anne Marie Hurley, A.B. (Emmanuel College), Instructor

Pasquale Condo, B.S. (Purdue University), M.S. (Lowell Technological Institute), Assistant Professor

Angelo Dadoly, B.S. (Boston University), M.Ed. (Boston State College), Assistant Professor

Robert K. Devejian, B.S. (Tufts University), M.A. (Boston University), Professor

Alan W. Doerr, B.A. (Marist College), M.A. (Hunter College), Assistant Professor

James H. Doherty, B.A. (University of New Hampshire), Associate Professor

M. Brendan Fleming, B.S., M.A. (Boston College), Professor

Michael Grossman, B.S. (Tufts University), M.A. (Yale University), Assistant Professor

Mary C. Hall, A.B. (Regis College), M.Ed. (Boston University), Associate Professor

Edward R. Hogan, A.B., M.A., Ph.D. (Syracuse University), Instructor

Alan Kaplan, B.S. (University of Massachusetts), M.S., Ph.D. (Syracuse University), Assistant Professor

Thomas G. Kudzma, S.B. (Massachusetts Institute of Technology), A.M. (Harvard University), Assistant Professor

Thomas F. McElligott, A.B. (Mt. St. Mary's College), Ed.M. (Boston University), Professor

C. Robert Montgomery, B.A. (Boston University), P.E., Assistant Professor

Joseph L. Neuringer, B.A. (Brooklyn College), M.A. (Columbia University), Ph.D. (New York University), Professor

Alexander A. Olsen, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Instructor

Andrew A. Oullette, B.S. (Brown University), Professor

Ira E. Over, Jr., B.S. (University of Maryland), M.S. (Xavier University), Assistant Professor

Peter D. Rosenbaum, A.B., Ph.D. (Massachusetts Institute of Technology), Instructor

Bernard Shapiro, B.S. (Lowell Technological Institute), S.M. (Massachusetts Institute of Technology), Associate Professor

Arthur D. Talkington, B.E. (University of Chicago), M.A. (University of Missouri), Associate Professor

Virginia S. Taylor, B.S. (Syracuse University), M.A. (Western Michigan University), Associate Professor

MATHEMATICS PROGRAM

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics — algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields of teaching and industry.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	3
MA	211	Fundamental Concepts in Mathematics	3
		Language Elective	3
		Technical Elective	3
		General Elective	3
		Total hours	15

Second Semester

MA	204	Calculus IV	3
MA	221	Linear Algebra	3
MA	361	Digital Computer Programming	2
		Language Elective	3
		General or Technical Elective	3
		General Elective	3
		Total hours	17

JUNIOR YEAR

First Semester

MA	301	Applied Mathematics I	3
MA	305	Introduction to Real Analysis I	3
		Mathematics Elective*	3
		Elective	3
		General Elective	3
		Total hours	15

*To be approved by the Department

Second Semester

MA	302	Applied Mathematics II	3
MA	306	Introduction to Real Analysis II	3
		Mathematics Elective*	3
		Elective	3
		General Elective	3
		Total hours	15

*To be approved by the Department

SENIOR YEAR

First Semester

MA	411	Complex Variables I	3
MA	421	Modern Algebra I	3
		Mathematics Elective*	3
		General or Technical Elective	3
		General Elective**	3
		Total hours	15

*To be approved by the Department
**ROTC students may substitute AS 401

Second Semester

Mathematics Elective*	3
Mathematics Elective*	3
Mathematics Elective*	3
General or Technical Elective	3
General Elective**	3
Total hours	15

*To be approved by the Department
**ROTC students may substitute AS 402

MATHEMATICS COURSE DESCRIPTIONS

MA 101 Mathematical Analysis I (3-0)3

Review of algebra, factoring, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, mathematical induction, progressions, logarithms, mathematics of investment, permutations and combinations.

MA 102 Mathematical Analysis II (3-0)3
[MA 101]

Calculus with applications in economics and management science: straight line, limits, tangent lines, derivatives, max-min problems, implicit differentiation, business applications to derivatives, integral calculus with applications to management science.

MA 103 **Calculus I** **(3-0)3**

Functions and graphs, equations of straight lines, differentiation of algebraic functions, differentials, maxima and minima; the indefinite integral and area under a curve.

MA 104 **Calculus II** **(3-0)3**

[MA 103]

Applications of integration including volume, length of arc, curvature, work and center of gravity. Methods of integration including parts, partial fractions and trigonometric substitution. Differentiation and integration of trigonometric functions and transcendental functions. Plane analytic geometry.

MA 201 **Mathematical Analysis III** **(3-0)3**

[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 **Mathematical Analysis IV** **(3-0)3**

[MA 201]

Linear programming with graphs and ordinary algebra, vecor algebra and matrix algebra used in linear programming, simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and appliations of calculus in business operations.

MA 203 **Calculus III** **(3-0)3**

[MA 104]

Hyperbolic functions. Determinants. Polar coordinates. Paraetric equations. Vector algebra, scalar and vector products, ector calculus, differentiation of vectors and their products, quations of lines, planes and surfaces. Partial derivatives, direconal derivative, gradient.

A 204 **Calculus IV** **(3-0)3**

[MA 203]

Exact differential. Multiple integrals including volumes, areas, nter of gravity and moments of inertia. Infinite series including ylor's theorem. Introduction to ordinary differential equations,

first order equations and linear equations with constant coefficients.

MA 211 Fundamental Concepts in Mathematics (3-0)3

The logic of mathematical operations. Quantified statements. Methods of proof. Disproofs. Elementary set theory. Ordered pairs and functions. Axiomatic introduction to the real number system including the Dedekind axiom and mathematical induction.

MA 221 Linear Algebra (3-0)3
[MA 211]

Vectors in R^n, vector spaces, matrices, linear mappings, matrix associated with a linear map, eigenvalues and eigenvectors, diagonalization of matrices, applications in R^n.

MA 301 Applied Mathematics I (3-0)3
[MA 204]

Vector analysis, review of vector algebra and vector calculus, divergence theorem, Green's Theorem and Stokes' Theorem; Ordinary differential equations, first order equations, linear equations with constant coefficients. Applications.

MA 302 Applied Mathematics II (3-0)3
[MA 301]

Series solution of ordinary differential equations, Bessel functions, Legendre functions. Ordinary differential equations boundary value problems, Fourier series and integrals. Partial differential equations of physics and engineering, separation of variables.

MA 303 Applied Mathematics III (3-0)3
[MA 204]

Algebra of vectors, matrices and determinants. Vector calculus. Vector and scalar fields. Coordinate transformations. Divergence Theorem. Green's Theorem. Stokes' Theorem. Eigenvalues, eigenvectors. Applications to physics and engineering.

MA 305 Introduction to Real Analysis I (3-0)3
[MA 211]

Equivalence and countability. Sets and sequences of real numbers. Metric spaces.

MA 306 Introduction to Real Analysis II (3-0)3
[MA 305]

Limits and continuity in metric spaces. The Riemann integral and the derivative.

MA 311 Applications of Linear Algebra (3-0)3
[MA 221]

Bilinear forms, Hamilton-Caley Theorem, the Spectral Theorem, Jordan normal form, matrix calculus. Applications to differential equations, Fourier series.

MA 315 Complex Variables for Engineers (3-0)3
[MA 204]

Complex variables with emphasis on Electrical Engineering applications. Analytic functions, Cauchy-Riemann conditions. Line integrals, Cauchy's integral formula and residues. Singularities. Taylor and Laurent series.

MA 334 Projective Geometry (3-0)3
[MA 211]

Foundations of geometry, homogenous coordinates, projective spaces, conics, linear transformations and surfaces.

MA 335 Differential Geometry (3-0)3
[MA 211]

Applications of analysis to the study of space curves and surfaces.

MA 361 Digital Computer Programming (2-0)2

Programming principles of the FORTRAN language including input-output, arithmetic, control and specification statements, subroutines and advanced techniques. Students will process several problems on the Institute's computer.

MA 362 Numerical Analysis (3-0)3
[MA 203 and MA 361]

Theory and application of numerical techniques including error analysis, linear, non-linear and differential equations, matrices, interpolation, numerical integration and curve fitting. Computer solutions are emphasized.

MA 363 Introduction to Computing (3-0)3

Types of computers and their operation. Characteristics, storage and calculation principles. Addressing schemes. Computer arithmetic and logic, numbering systems, instruction codes, input-output organization and devices.

MA 371 Number Theory (3-0)3

[MA 211]

Congruences and residue classes, quadratic residues. Diophantine equations, number theoretic functions, distribution of primes.

MA 381 Operations Research I (3-0)3

[MA 104 or MA 102]

The use of decision models in industrial systems. Quantitative approach to the industrial alternative. Fundamentals of probability and statistics, PERT techniques, methods of optimization using calculus, inventory control models and queuing models.

MA 382 Operations Research II (3-0)3

[MA 381]

A continuation of MA 381. Topics include: linear programming, transportation models, nonlinear programming, dynamic programming, games and strategies. Markov analysis, and simulation techniques.

MA 383 Introduction to Statistics (3-0)3

Sets and probability laws, random variables, mathematical expectation, measure of central tendency and variance. Study of discrete and continuous probability distribution, sampling theory, tests of hypothesis. Regression and correlation.

MA 407 Introduction to Probability Theory (3-0)3

[MA 204]

Probability functions and densities, expectations. Moments of probability distributions. Central limit theorem.

MA 408 Introduction to Mathematical Statistics (3-0)3

[MA 407]

Sampling, decision theory, estimation, hypothesis testing regression and correlation.

MA 421 Modern Algebra I (3-0)3
[MA 221]

Elementary group theory; groups, cosets, normal subgroups, quotient groups, isomorphisms, homomorphisms, series of groups, the Sylow Theorems, free groups and homology groups.

MA 422 Modern Algebra II (3-0)3
[MA 421]

Elementary ring and field theory, quotient rings and ideals, homomorphisms of rings, rings of polynomials, algebraic extensions, automorphisms of fields, separable extensions. Galois Theory. Introduction to categories and functors.

MA 431 Topology I (3-0)3
[MA 211]

Cardinality, partially ordered sets and Zorn's lemma, topology of the line and plane, topological spaces, continuity and topological equivalence.

MA 432 Topology II (3-0)3
[MA 431]

Metric and normed spaces, compactness, connectedness, product spaces, function spaces, fundamental group.

MA 433 Matrix Theory (3-0)3
[MA 204]

Algebra of vectors, matrices and determinants. Linear transformations and vector spaces. Characteristic values and diagonal forms. Calculus of matrices, matric polynomials. Matric differential equations. Applications.

MA 442 Boundary Value Problems (3-0)3
[MA 204]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics and engineering, and boundary value problems.

MA 445 Operational Calculus (3-0)3
[MA 204]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentia-

tion and integration. Applications in the analysis of vibrations, deflections, and electric circuits, problems in partial differential equations, and Fourier transforms.

MA 452 Applications of Numerical Analysis (3-0)3
[MA 204 and MA 361]

Iterative solutions of transcendental equations. Rapidity of convergence and error estimates. Numerical differentiation and integration. Extrapolation and Romberg quadrature, interpolation, numerical solution of ordinary differential equations. Predictor-corrector formulas. Partial differential equations. Applications, computer solutions.

MA 471 Optimization and Mathematical Programming I (3-0)3
[MA 204]

Linear programming, simplex method, transportation problems, applications. Convex programming, Chebyshev approximation.

MA 472 Optimization and Mathematical Programming II (3-0)3
[MA 471]

Convex programming, Kuhn-Tucker Theorem; Geometric programming, Dual Function, Optimum design problems; Dynamic Programming, Calculus of Variations.

MA 475 Mathematical Logic (3-0)3
[MA 211]

Propositional and statement logic. A rigorous development of the science of deductive logic with an emphasis on the nature of the logical structure underlying mathematical systems.

MA 497 Foundations of Mathematics (3-0)3
[Senior Standing]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 498 Mathematics Seminar (3-0)3
[Senior Standing]

Student reading, writing and criticism, topics from current literature, and review of some important elements of the undergraduate work.

MA 501 Advanced Real Analysis I (3-0)3

Introduction to the real and complex number systems, elements of set theory including the Bolzano Weierstrass and Heine-Borel theorems, numerical sequences and series, continuity.

MA 502 Advanced Real Analysis II (3-0)3

Differentiation, Riemann integration, sequences and series of functions, and functions of several variables.

MA 511 Complex Analysis I (3-0)3

Complex numbers and their geometric representation, linear functions, sets and sequences and power series, analytic functions and conformal mappings, elementary functions, complex integration and integral theorems.

MA 512 Complex Analysis II (3-0)3

Series and the expansion of analytic functions in series, singularities, single valued functions, entire functions, meromorphic functions, periodic functions.

MA 537 Tensor Analysis I (3-0)3

Tensor algebra in affine coordinates in n-dimensional space, algebra and calculus of covariant and contravariant tensors and tensor densities, covariant differentiation and parallel displacement, curvature tensors.

MA 538 Tensor Analysis II (3-0)3

Applications of tensor analysis to differential geometry of Riemannian spaces, analytical dynamics, mechanics of continuous media and theory of relativity.

MA 545 Partial Differential Equations I (3-0)3

First and second order partial differential equations, transformation theory in the plane and space. Applications to mathematical physics.

MA 546 Partial Differential Equations II (3-0)3

Classification and methods of solution. Properties of solutions of equations with initial and boundary conditions. Existence and uniqueness theorems.

MA 547 Integral Equations (3-0)3

Exact, iterative and numerical techniques for the solution of linear Volterra and Fredholm integral equations; theorems for general operators; symmetric kernels, orthogonal system of functions and the Hilbert-Schmidt theorem; relation of integral equations to differential equations; applications of the Rayleigh-Ritz, Galerkin, and variation-iteration techniques to the solutions of eigenvalue-eigenfunction problems occurring in Mathematical Physics and Engineering.

MA 551 Calculus of Variations (3-0)3

The first variational problem; necessary conditions; Euler's equation. Generalization to several dependent and independent variables. Constraints and Lagrange multipliers. Applications to dynamics and elasticity. Hamilton equations. Sturm-Liouville problems, direct methods; Rayleigh-Ritz method.

MA 563 Advanced Numerical Analysis I (3-0)3

Iterative solutions of non-linear equations. Interpolation, numerical differentiation and integration. Summation of series. Least squares approximation, orthogonal polynomials. Chebyshev approximation. Ill-conditioning. Computer applications.

MA 564 Advanced Numerical Analysis II (3-0)3

Systems of linear equations. Gauss eliminations, LU decompositions. Wilkinson round-off error analysis. Scaling and condition number. Iterative methods. Application to elliptic partial differential equations. Applications to structural analysis. Computer solutions.

MA 584 Analysis of Random Processes (3-0)3

Axiomatic definition of Probability. Combined Experiments, Bernoulii Trials, Asymptotic Theorems, Bayes Theorem. The concepts of both discrete and continuous random variables, and functions of one or more random variables. The use of continuous probability density functions to describe both discrete and continuous phenomena. Expected value, moments, characteristic functions, mean square estimation. Sequences of continuous random variables, convergence concepts, law of large numbers, Central Limit Theorem.

Department of Meteorology

Robert C. Curtis, A.B. (Williams College), Ph.D. (Pennsylvania State University), Professor and Chairman

Geoffrey E. Hill, B.S., M.S. (Massachusetts Institute of Technology), Associate Professor

Ashton G. Peyrefitte, B.S., M.S. (Florida State University), Instructor

Wen Tang, B.S. (National Central University, China), M.S., Ph.D. (New York University), Associate Professor

METEOROLOGY PROGRAM

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of weather for the general public to the analysis of the influence of weather and climate on public health and on particular operations in agriculture, engineering, industry and commerce and national defense.

Meteorologists are employed by the agencies of The National Oceanic and Atmospheric Administration, especially the National Weather Service, and of the Department of Defense as well as by the agencies of state and local governments, commercial aviation companies, and private consulting firms.

Research in meteorology and climatology is conducted by the agencies of the U. S. Government, universities, and industrial research companies. Graduate training is essential for advancement in this field and most employers provide opportunities for capable individuals to acquire this training.

The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MY	211	Elementary Meteorology	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	16

Second Semester

MA	204	Calculus IV	(3-0)3
MY	212	Elementary Meteorology	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
MY	301	Atmospheric Dynamics	(3-0)3
MY	308	Synoptic Meteorology	(2-3)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
MY	302	Atmospheric Dynamics	(3-0)3
MY	307	Tropical Meteorology	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

MY	403	Physical Meteorology	(3-0)3
MY	415	Advanced Atmospheric Dynamics	(3-0)3
MY	421	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may elect AS 401.

Second Semester

MY	413	Oceanography	(3-0)3
MY	416	Advanced Atmospheric Dynamics	(3-0)3
MY	422	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	15

*ROTC students may elect AS 402.

METEOROLOGY COURSE DESCRIPTIONS

MY 211 Elementary Meteorology (3-0)3
[MA 104, PH 102]

Synoptic and mean spatial variations of pressure, temperature and velocity. Cyclones, anticyclones, fronts waves and jet streams. Elements of atmospheric thermodynamics and hydrodynamics; the equation of state, first law of thermodynamics, hypsometric equation, stability of hydrostatic equilibrium, thermal circulation, geostrophic and gradient motion, thermal wind.

MY 212 Elementary Meteorology (3-0)3
[MY 211]

Atmospheric and solar radiation. Atmospheric heat budget. Distribution and causes of fog, clouds, precipitation, thunderstorms and tornados. Elements of general circulation theory and tropical meteorology.

MY 301 Atmospheric Dynamics (3-0)3
[MY 211]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium and its stability. Convection theory. The equations governing large-scale frictionless motion in the atmosphere. Steady state motion.

MY 302 Atmospheric Dynamics (3-0)3
[MY 301]

Unsteady motion: development of thermal circulations: barotropic and baroclinic conditions, circulation, vorticity and divergence; mechanism of pressure change; Sutcliffe development and elements of numerical weather prediction.

MY 307 Tropical Meteorology (3-0)3
[MY 206]

An introduction to tropical meteorology. Distribution of temperature, water vapor and velocity. Observations from aircraft, satellites and radar. Analysis of tropical data. Air sea interaction; convection and clouds. The trade wind region and intertropical convergence zone. Easterly waves and tropical storms.

MY 308 Synoptic Meteorology (2-3)3
[MY 206]

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network.

MY 313 Physical Climatology (3-0)3
[MY 212]

Measurements and observations. Statistical methods. Atmospheric processes determining the climate; solar and terrestrial radiation, elevation and thermal properties of surfaces, atmospheric circulations and interactions between the atmosphere and land or sea surfaces, hydrological cycle.

MY 403 Physical Meteorology (3-0)3
[MY 302]

Solar and terrestrial radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; radiative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion.

MY 413 Oceanography (3-0)3
[MY 302]

Physical properties of sea water. Distribution of pressure, temperature and salinity. Heat budget. Theories of wind-driven and thermal circulations. Transfer processes. Waves and tides. General circulation theory.

MY 415 Advanced Atmospheric Dynamics (3-0)3
[MY 302]

Atmospheric discontinuities. Viscosity, turbulence and energy dissipation. Perturbation theory of wave motions. Numerical weather prediction techniques and models.

MY 416 Advanced Atmospheric Dynamics (3-0)3
[MY 415]

Stability of atmospheric circulations. General circulation theory and models. Thermal convection.

MY 421 Analysis and Forecasting (1-6)3
[MY 302, MY 308]

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting.

MY 422 Analysis and Forecasting (1-6)3
[MY 421]

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures.

MY 425 Statistical Methods in Meteorology (3-0)3
[MY 302]

Frequency distributions and their properties. Sampling theory and techniques. Relationships between variables. Analysis of time series and of spatial variation. Statistical forecasting and forecast verification. Factor analysis and experimental design.

MY 430 Atmospheric Diffusion (3-0)3
[Permission of Instructor]

Study of the meteorological processes that affect the diffusion and removal of atmospheric pollutants: theories of diffusion and their application to the calculation of concentrations; the effects of buildings and topography on atmospheric diffusion; meteorological factors involved in the design and location of stacks.

MY 441 Research Project (0-9)3

An individual or team research project carried out by qualified seniors under supervision of a faculty member.

Department of Physics and Applied Physics

Gunter H. R. Kegel, F.N.Fi (Universidade do Brasil), Ph.D. (Massachusetts Institute of Technology), Professor and Chairman

Albert Altman, B.S. (Brooklyn College), M.S., Ph.D. (University of Maryland), Professor

Adolph Baker, B.A., M.S. in Ed. (City College of New York), B.M.E. (Brooklyn Polytechnic Institute), M.S. (New York University), Ph.D. (Brandeis University), Professor

Luther C. Barcus, B.A. (University of Delaware), M.S. (Miami University), Associate Professor

Barry K. Barnes, B.A., M.A., Ph.D. (Rice University), Assistant Professor

Leon E. Beghian, B.A., Ph.D. (University of Oxford), Professor and Provost

C. Daniel Cole, B.A., M.A., Ph.D. (University of Buffalo), Professor

Gus P. Couchell, B.S., M.S. (North Carolina State University), Ph.D. (Columbia University), Associate Professor

James J. Egan, B.A. (Thomas More College), M.S., Ph.D. (University of Kentucky), Assistant Professor

Ian A. Forbes, B.S. (Memorial University of Newfoundland), Ph.D. (Massachusetts Institute of Technology), Assistant Professor

Zoltan Fried, B.S. (Brooklyn College), Ph.D. (Brandeis University), Professor

F. Raymond Hardy, B.S., M.S. (Lowell Technological Institute), Professor

Padmanabh Harihar, B.S. (R. Ruia College), M.S. (Wilson College), Ph.D. (Columbia University), Associate Professor

Lloyd C. Kannenberg, S.B. (Massachusetts Institute of Technology), M.S. (University of Florida), Ph.D. (Northeastern University), Associate Professor

Aram S. Karakashian, B.A., M.A. (Temple University), Ph.D. (University of Maryland), Assistant Professor

David Korff, B.A. (Harvard University), Ph.D. (Brandeis University), Professor

Wayne K. Lehto, B.S., M.S. (Michigan Technological University), Ph.D. (University of Michigan), Associate Professor

Thomas V. Marcella, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Assistant Professor

Suresh C. Mathur, B.Sc., M.Sc. (University of Lucknow), Ph.D. (University of Texas), Professor

Roger D. McLeod, B.A. (Bowdoin College), M.S. (Lowell Technological Institute), Associate Professor

Walter Roy Mellen, B.S. (Massachusetts Institute of Technology), M.S. (Lowell Technological Institute), Associate Professor

Arthur I. Miller, B.S. (City College of New York), Ph.D. (Massachusetts Institute of Technology), Associate Professor

Arthur Mittler, B.A. (Drew University), M.S., Ph.D. (University of Kentucky), Assistant Professor

M. Ali Omar, B.S. (Colorado School of Mines), M.S., Ph.D. (University of Colorado), Professor

James P. Phelps, B.S. (University of Maine), Ph.D. (Michigan State University), Adjunct Associate Professor

David J. Pullen, B.Sc. (King's College, University of London), D. Phil. (Trinity College, University of Oxford), Associate Professor

Paul J. Ring, B.S. (Boston College), Ph.D. (Brown University), Assistant Professor

Alexander Sachs, B.S. (Northwestern University), Instructor

Walter A. Schier, B.S. (St. Procopius College), Ph.D. (University of Notre Dame), Associate Professor

Kunnat J. Sebastian, B.S., M.S. (University of Kerala), Ph.D. (University of Maryland), Assistant Professor

Eric Sheldon, B.Sc., B.Sc., Ph.D., D.Sc. (University of London), Professor

Malcolm K. Smith, B.S. (Haverford College), M.A. (Columbia University), Professor

Richard W. Stimets, B.S., Ph.D. (Massachusetts Institute of Technology), Assistant Professor

Constantine P. Tzanos, Dipl. Ch. Eng. (National Technical University of Athens), Ph.D. (Massachusetts Institute of Technology), Instructor

Jerry Waldman, B.A., M.A. (Columbia University), Ph.D. (Massachusetts Institute of Technology), Assistant Professor

Martin Wilner, B.S. (Rensselaer Polytechnic Institute), M.S. (Yale University), Ph.D. (Massachusetts Institute of Technology), Professor

Chuen Wong, Dipl of Sci. (Chong Chi College, Hong Kong), Ph.D. (Case Institute of Technology), Assistant Professor

Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), Professor

PHYSICS PROGRAM

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

SOPHOMORE YEAR

First Semester

PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	209	Physics	(4-0)4
PH	293	Experimental Physics	(2-6)4
		Elective	(3-0)3
		Total hours	(13-6)15

Second Semester

PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	210	Physics	(4-0)4
PH	294	Experimental Physics	(2-6)4
		Elective	(3-0)3
		Total hours	(13-6)15

JUNIOR YEAR

First Semester

PH	311	Intermediate Mechanics	(3-0)3
PH	335	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	393	Intermediate Laboratory	(0-6)2
		Elective	(3-0)3
		Total hours	(12-6)14

Second Semester

PH	312	Intermediate Mechanics	(3-0)3
PH	336	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	394	Intermediate Laboratory	(0-6)2
		Elective	(3-0)3
		Total hours	(12-6)14

SENIOR YEAR

First Semester

PH	423	Thermodynamics	(3-0)3
		Elective	(3-0)3
		Elective	(3-0)3
		Elective	(3-0)3
		Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may elect AS 401.

Second Semester

PH	424	Introduction to Statistical Mechanics	(3-0)3
		Elective	(3-0)3
		Elective	(3-0)3
		Elective	(3-0)3
		Elective*	(3-0)3
		Total hours	(15-0)15

*ROTC students may elect AS 402.

Electives may be either general or technical and may be chosen from among all of the courses offered by the Institute subject to the following conditions:

1. They must be approved by the student's advisor.
2. At least six electives must be general.
3. No more than ten general electives may be used to satisfy the elective requirements of the curriculum.
4. At least two electives must be chosen in the social sciences and two in languages and literature.

5. At least two electives must be chosen in some foreign language, usually French, German, or Russian, both electives being chosen in the same foreign language. This requirement may be used to partially satisfy those in 2 and 4.

PHYSICS COURSE DESCRIPTIONS

PH 101 Physics (4-1)4

Mechanics: kinematics; dynamics — inertia, mass, momentum, force, impulse, application of Newton's laws, inertial and noninertial frames of reference.

PH 102 Physics (4-1)4
[PH 101 or equivalent]

Work, energy, rotational kinematics and dynamics, angular momentum, gravitation, elasticity, and simple harmonic motion. Temperature, ideal gases, kinetic theory, thermal properties of solids and liquids, 1st and 2nd laws of thermodynamics, Carnot cycle, entropy.

PH 201 Physics (4-1)4
[PH 102, MA 104]

Elements of Electricity and Magnetism: Coulomb's law, electric fields and potential, Gauss' law, d-c circuits, magnetic fields, Ampere's law, Faraday's law, displacement current, elctromagnetic waves.

PH 202 Physics (4-1)4
[PH 201]

Waves: general phenomena, beats, Doppler effect, reflection, standing waves. Optics: reflection, refraction, geometrical optics, interference, diffraction, polarization. Introduction to modern physics: special relativity, quantum effects, Bohr theory of the atom, atomic and molecular spectra, and applications.

PH 207 Mathematical Techniques of Physics I (4-0)4
[MA 104]

Partial differentiation, determinants; Cartesian coordinates, orthogonal transformations, algebra of scalars and Cartesian vec-

tors; differentiation of scalar and vector fields; multiple integrals, Green's, Stokes', Gauss' theorems; applications to Newtonian mechanics; solutions of first order and linear second order differential equations.

PH 208 Mathematical Techniques of Physics II (4-0)4

[PH 207]

Series of constants and functions, Taylor's series; solutions of linear differential equations by generalized power series; introduction to functions of a complex variable; eigenvalue problems and Fourier series; partial differential equations in physics.

PH 209 Physics (4-0)4

[PH 102]

[For Physics majors only]

Electrostatics: electric charge, Coulomb's law, electric field, Gauss' law, electrical potential, capacitance, and dielectrics; electrodynamics: electric current, resistance, Ohm's law, resistivity, electromotive force, d-c circuits, magnetic field, magnetic dipole moment, Biot-Savart law, Ampere's law, Faraday's law, inductance, and Maxwell's equations.

PH 210 Physics (4-0)4

[PH 209]

[For Physics majors only]

Waves: general representation, superposition, interference, standing waves, beats, and Doppler effect; acoustic waves; optics: history, law of reflection, law of refraction, Huyghens' principle, mirrors, thin lenses, interference, Fraunhofer diffraction, electromagnetic waves, and the ether; experiments and theo-
multiple slits, diffraction grating, polarization, speed of light,

PH 293-294 Experimental Physics (2-6)(2-6)8

[PH 102]

A course in experimental methods, with related theoretical material. Experiments principally in electrical measurements, along with a number in optics, heat, mechanics, and atomic physics. Lectures in laboratory techniques and practices, elementary theory of errors, and basic d-c and a-c circuit theory. Laboratory and theory are integrated.

PH 311 Intermediate Mechanics (3-0)3

[PH 208]

Orthogonal coordinate transformations and rotational matrices, analysis of Newton's laws of motion, conservation laws

for one particle and many particle systems, gravitational potential, conservative and nonconservative forces, linear oscillations, driven oscillations (including electrical analogs, Fourier series, impulsive forces, Green's function), central force motion, and kinematics and elastic collisions for two particle systems.

PH 312 Intermediate Mechanics (3-0)3
[PH 311]

Calculus of variations, generalized coordinates, Lagrangian mechanics, Hamiltonian function, noninertial frames of reference, rotational dynamics of rigid bodies (including inertia tensor, principal axes of inertia, Eulerian angles, motion of a top), coupled oscillators, and normal coordinates.

PH 335 Modern Physics (3-0)3
[PH 208, PH 210]

Special theory of relativity: Einstein's postulates and assumptions, Lorentz transformation, simultaneity, time dilation, space contraction, velocity transformation, Minkowski space, four vectors, proper time, Newton's second law of motion, conservation laws, center of mass, and collision problems; atomic theory: elements of chemistry, Faraday's laws of electrolysis, discharge tubes, the electron, Millikan's oil drop experiment, black body radiation, Rayleigh-Jean's radiation law, Planck's radiation law, photoelectric effect, X-rays, Compton effect, and wave-particle duality.

PH 336 Modern Physics (3-0)3
[PH 335]

Old quantum theory: history of atomic spectroscopy, Rutherford scattering, Bohr model of the atom, Franck-Hertz experiment, Bohr-Sommerfeld model, electron spin, vector model, Zeeman effect, Pauli exclusion principle, and spectroscopic nomenclature; modern quantum theory: de Broglie waves, Stern-Gerlach experiment, Schroedinger equation, Heisenberg uncertainty principle, and applications of the theory to the simple harmonic oscillator and the hydrogen atom.

PH 353 Electromagnetic Theory (3-0)3
[PH 208, PH 209]

The theory of electromagnetic fields using vector analysis and Maxwell's equations: static electric and magnetic fields in conductors and dielectrics, scalar and vector potentials, solutions to Laplace's equation, image charge problems, and energy density problems.

PH 354 Electromagnetic Theory (3-0)3
[PH 353]

Time-varying electromagnetic fields, ferromagnetic materials, propagation of plane waves in conductors and dielectrics, Snell's law, Fresnel equations, polarization, and radiation from accelerated charges and antennas.

PH 393-394 Intermediate Laboratory (0-6) (0-6)4
[PH 294]

Advanced experiments in various branches of physics, principally optics and atomic physics, with opportunities for some independent work by permission of the instructor. Detailed written reports are required.

PH 423 Thermodynamics (3-0)3

Review of classical thermodynamics: macroscopic description of temperature, equilibrium and heat, the first and second laws of thermodynamics in terms of heat engines; entropy; microscopic foundations of thermodynamics: probability and statistical methods, microscopic and macroscopic states of physical systems, ensembles, density of states, and phase space; microscopic definitions of equilibrium, heat, temperature, reversible and irreversible processes, and entropy; the zeroth, first, second, and third laws of thermodynamics, equations of state, TdS equations, enthalpy, Helmholtz and Gibbs functions, Maxwell's relations and applications.

PH 424 Statistical Mechanics (3-0)3
[PH 423]

A continuation of PH 423. Methods of statistical mechanics: Gibbs' microcanonical, canonical, and grand canonical ensembles; partition function; the equipartition theorem; phase transitions; quantum statistics: Bose-Einstein and Fermi-Dirac statistics and the Maxwell-Boltzmann classical limit; applications to radiation, magnetism, specific heats, and ideal and non-ideal systems; kinetic theory and transport processes.

PH 441 Introduction To Relativity and Quantum Mechanics (3-0)3
[PH 336, PH 312, PH 354]

Covariance of physical laws, Lorentz transformation, relativistic mechanics, tensor analysis, proper time, Minkowski force, particle collisions, relativistic electrodynamics, field tensor. Experimental basis for interference of particles and the uncertainty

principle; postulates of quantum mechanics, operators hermiticity, commutativity, orthogonality of eigenfunctions.

PH 442 Introduction to Relativity and Quantum Mechanics (3-0)3

[PH 441]

First order perturbations of energy levels, harmonic oscillator, free particle, one electron atom, hydrogen fine structure, Pauli principle and atomic shell structure.

PH 461 Nuclear Physics (3-0)3

[PH 336 and Permission of Instructor]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, and systematics of alpha and beta decay. Elementary quantum mechanics will be used extensively.

PH 462 Nuclear Physics (3-0)3

[PH 461]

Alpha decay theory, gamma emission, two nucleon systems, nuclear reactions, nuclear structure, and properties of neutrons.

PH 471 Solid State Physics (3-0)3

[PH 336, PH 354]

Crystal structure, crystal diffraction, crystal binding, elastic waves, phonons, lattice vibrations, thermal properties of insulators and the free electron gas.

PH 472 Solid State Physics (3-0)3

[PH 471]

Energy bands, semiconductor crystals, superconductivity, dielectric and magnetic properties of solids, optical phenomena in insulators, point defects, alloys, and dislocations.

PH 495 Special Research Problems (3-0)3

[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student with emphasis on modern research methods and preparation of results for publication.

PH 496 Special Research Problems (3-0)3

[Permission of Head of Department and Instructor]

Continuation of PH 495 for a second semester.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well qualified undergraduate students.

PH 505-506 Mathematical Methods of Physics (3-0) (3-0)6

[Permission of Instructor]

Complex variables: Cauchy's theorem, Taylor and Laurent series, analytic continuation, the residue theorem, the gamma function, the saddle point approximation, asymptotic series. Fourier series. Fourier and LaPlace transforms. Partial differential equations and boundary value problems. Ordinary second order differential equations. Legendre functions, Bessel functions, other special functions. The Sturm-Liouville problem, eigen functions and eigen-values. Green's Functions. Integral equations.

PH 507 High-Energy Physics (3-0)3

[Permission of Instructor]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, dispersion relations, Regge poles and unitary symmetry.

PH 511-512 Classical Mechanics (3-0) (3-0)6

[Permission of Instructor]

Variational principles and Lagrange's equations, holonomic and non-holonomic constraints. Hamilton's principle, Central force motion. Orthogonal transformations, rigid body motion. Principle of least action, canonical transformations, Poisson brackets, Hamilton-Jacobi theory. Small oscillations. Classical field theory.

PH 515-516 Quantum Mechanics (3-0) (3-0)6

[Permission of Instructor]

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory.

PH 517-518 Advanced Quantum Mechanics (3-0) (3-0)6
[Permission of Instructor]

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Second quantization and canonical commutation rules, the connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 521-522 Statistical Mechanics (3-0) (3-0)6
[PH 424 and Permission of Instructor]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 557-558 Electricity and Magnetism (3-0) (3-0)6
[Permission of Instructor]

Electrostatics and magnetostatics with special attention to boundary value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561-562 Nuclear Physics (3-0) (3-0)6
[PH 462 and Permission of Instructor]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 573-574 Quantum Theory of Solids (3-0) (3-0)6
[PH 442 and Permission of Instructor]

Crystal structure and symmetry. Lattice vibrations and interaction with radiation. Band theory in the one-electron approximation. Metals and semiconductors and transport, plasma and optical properties. Many-body theory; Magnetism; Electronphonon interaction; Superconductivity; Disordered systems.

PH 575-576 Neutral Particle Transport (3-0) (3-0)6
[Permission of Instructor]

Boltzmann and integral transport equations. Spherical harmonic and variational methods. Corrections to diffusion theory.

Special methods of solving transport equations. Adjoint functions. Applications.

PH 583-584 General Theory of Relativity (3-0) (3-0)6
[Permission of Instructor]

Review of Newtonian gravitational theory and special relativity. The weak and strong principles of equivalence. Tensor analysis in Riemann spaces. Einstein's equations for the gravitational field. Classic tests of Einstein's theory; spherically symmetric solutions. Gravitational field theory and the canonical analysis of general relativity.

PH 593-594 Graduate Laboratory (0-9) (0-9)6
[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 942 Physics (3-2)4
[46.22]
[For Engineering Technology students only]

Elements of electricity and magnetism: Coulomb's law, electric fields, Gauss' law, potential, current, dc circuits, magnetic fields and forces, induced emf, ac circuits.

Industry Advisory Committee

Nuclear

Dr. Ernest F. Blase, E G & G, Inc.
Mr. Roger J. Coe, Yankee Atomic Electric Company
Mr. Joseph J. Fitzgerald, Cambridge Nuclear Corporation
Dr. Thomas H. Johnson
Dr. Jacob H. Jurmain, E G & G, Inc.
Dr. Marvin G. Schorr, Technical Operations, Inc.

NUCLEAR ENGINEERING PROGRAM

The Nuclear Engineering course is offered by the Department of Physics and Applied Physics. It was the first course of its kind taught in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

Six general electives are required and can be selected from the elective system with the exception of LL 261-262 and EC 301 through EC 414.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	242	Thermodynamics	(3-0)3
NU	301	Nuclear Engineering	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
		General Elective	(3-0)3
		Total hours	(14-4)16

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
MA	302	Advanced Calculus for Applications	(3-0)3
NU	302	Nuclear Engineering	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
		General Elective	(3-0)3
		Total hours	(13-7)16

SENIOR YEAR

First Semester

ME	382	Fluid Mechanics I	(3-0)3
NU	401	Advanced Nuclear Reactor Engineering	(3-0)3
NU	497	Computer Programming and Applications I	(3-2)3
RS	401	Principles of Radiation Safety and Control*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-2)15

*ROTC students may substitute AS 401

Second Semester

ME	343	Heat Transfer	(3-0)3
NU	402	Advanced Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(12-6)15

*ROTC students may substitute AS 402

APPROVED TECHNICAL ELECTIVES

EE	446	Digital Devices and Techniques	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
NU	495	Special Nuclear Problems	(3-0)3
NU	498	Computer Programming and Applications II	(3-2)3
NU	499	Computer Methods and Numerical Analysis	(3-0)3
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3

NUCLEAR ENGINEERING COURSE DESCRIPTIONS

NU 201 Introduction to Nuclear Engineering (3-0)3

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear srtucture. Neutrons and fission.

NU 202 Introduction to Nuclear Engineering (3-0)3

Utilization of nuclear energy. Nuclear Reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 301 Nuclear Engineering (3-0)3

Nuclear forces and energy; semi-empirical mass formula; binding energy; fission; reactors; radioactivity; interaction of radiation with matter; neutron cross sections, temperature, flux; diffusion theory.

NU 302 Nuclear Engineering ((3-0)3

Neutron lethargy; Fermi age theory; the unreflected reactor; one-group, two-group, age-diffusion theories; reflector savings; homogeneous reactor systems; heterogeneous reactor systems; slightly-enriched, water-moderated lattice systems; fast breeder reactors; reactor kinetics, reactor temperature coefficients; fission product poisoning, reactor control and operation.

NU 305 Nuclear Instrumentation (2-4)4

The lectures review the interaction of nuclear radiation with matter, the design and operating characteristics of nuclear detectors and their use. The laboratory is devoted to studying the characteristics of detectors, their use in nuclear experiments dealing with radioactive decay and properties of nuclear radiation.

NU 306 Nuclear Instrumentation (2-4)4

The lectures cover the fundamentals of circuit theory as applied to pulse circuits encountered in nuclear counting systems. The laboratory offers experiments involving: the study of the characteristics of vacuum tubes and transistors; construction and operating characteristics of power supplies, amplifiers and oscillators; the principles of feedback; construction of pulse and digital circuits; binary, mono and astable circuits; trigger and coincidence circuits.

NU 401 Advanced Nuclear Engineering (3-0)3

Energy removal: design of the cooling system, heat transmission principles, heat-transfer characteristics of fluids, heat transfer to boiling liquids, core hydraulics, reactor coolants. Reactor structural and moderator materials; reactor fuels: separation of isotopes, material properties, reprocessing, waste disposal.

NU 402 Advanced Nuclear Engineering (3-0)3

Principles of reactor shielding; thermal stresses in reactor components; pressure vessel design; mechanical and structural components; preliminary reactor design: pressurized-water reactor, thermal and hydraulic design, shield design, mechanical

design, fuel utilization; fluid-fuel reactors; space power units; nuclear power costs.

NU 494 Advanced Nuclear Laboratory (0-6)3

Neutron activation experiments. Flux mappings by foil and counter techniques. Measurements of slowing down lengths, diffusion lengths and Fermi age. Control rod studies and effects of poisoned moderators. Additional experiments on accelerator and reactor using advanced instrumentation and techniques.

NU 495 Special Nuclear Problems ((3-0)3

[Permission of Head of Department and Instructor]

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

NU 496 Special Nuclear Problems (3-0)3

[Permission of Head of Department and Instructor]

Continuation of NU 495 for a second semester.

NU 497 Computer Programming and Applications I (3-2)3

Number systems including binary, octal, hexadecimal and interconversions. General description of modern digital computer systems. Programming in FORTRAN IV language. A survey of the computer system software.

NU 498 Computer Programming and Applications II (3-2)3

Programming in symbolic assembly language. Introduction to systems programming. Applications of computer programming in nuclear engineering and physics problems, using both the FORTRAN IV and assembly languages.

NU 499 Computer Methods and Numerical Analysis (3-0)3

Computer methods in the solution of engineering and physics problems using numerical analysis techniques. Topics include: error analysis, solution of algebraic, transcendental and polynominal equations, quadrature formulas for numerical integration, systems of linear equations, matrix manipulation, interpolation techniques, numerical differentiation, solution of differential equations, and curve fitting using linear and nonlinear least square methods.

NU 505 Reactor Physics (3-0)3

Nuclear reactions induced by neutrons: cross sections, fission; diffusion and slowing down of neutrons; Diffusion, Fermi age and multigroup treatment of unreflected and reflected homogeneous reactors, reactor design parameters.

NU 506 Reactor Physics (3-0)3

Reactor physics problems relating to the operation and kinetics of a nuclear reactor. Effect of poisoning, and temperature on design criteria; excess reactivity; elementary reactor kinetics, perturbation theory and control rod theory. Introduction to transport theory.

NU 507 Reactor Engineering (3-0)3

Analysis of nuclear energy conversion and removal from nuclear fueled reactors. Detailed analysis of heat generation and heat transfer including fluid dynamics of various reactor systems.

NU 508 Reactor Engineering (3-0)3

Continuation of NU 507. Analysis of reactor systems including power cycles, heat transfer, fuel management, economic analysis and basic reactor control theory.

NU 509 Fast Reactors (3-0)3

General characteristics of fast reactors. Breeding cycles and plutonium production; neutron balance, breeding ratio and doubling time. Simplified methods for fast reactor calculations. Kinetics, control and safety of fast reactors; sodium void and doppler coefficients. Engineering consideration and design concepts in large, fast power reactors.

Department of Radiological Sciences

Kenneth W. Skrable, B.S. (Moravian College), M.S. (Vanderbilt University), Ph.D. (Rutgers University), Certified Health Physicist; Professor and Chairman

Edward L. Alexander, B.S., M.S. (University of Maine), Ph.D. (Vanderbilt University), Professor and Dean of the Graduate School

George E. Chabot, Jr., A.B. (Harvard University), M.S. (Harvard School of Public Health), Certified Health Physicist; Adjunct Assistant Professor

Jesse Y. Harris, B.S., M.S., Ph.D. (Rutgers University), Professor

Anthony Liuzzi, B.S. (Rensselaer Polytechnic Institute), M.S., Ph.D. (New York University), Certified Health Physicist; Associate Professor

James P. Phelps, B.S. (University of Maine), Ph.D. (Michigan State University), Adjunct Associate Professor

RADIOLOGICAL HEALTH PHYSICS PROGRAM

The Radiological Health Physics Program offered by the Department of Radiological Sciences is designed to provide needed professional personnel to help advance the safe utilization of nuclear energy and radiation. It is conducted through the cooperation of other departments and provides the best education and experience within the practical limitations imposed by time and resources to carefully selected and highly motivated students. The program is supported by the Bureau of Radiological Health of the Department of Health, Education and Welfare. The program includes specialized training and education during the summer months, summer internship programs, and scholarships for qualified students.

The academic program is broad based in the basic sciences so that students will be able to recognize and appreciate the many complex and interrelating factors in the solution of problems facing the nuclear industry.

Students will benefit from cooperative summer training programs utilizing the radiation facilities and staff of the LTI Nuclear Center, government laboratories, industries, and major hospitals. This training and education in the nuclear sciences and radiological health gives experience with equipment and methods characteristic of current techniques and philosophy of professional practice in the radiation protection field. The summer program enables students to better select a professional position after graduation and better equips them for the pursuit of advanced degrees and research in the field.

Summer

RS	100	Basic Radiological Health Physics	4 weeks

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(16-5)17

Second Semester

BI	202	Principles of Biology	(3-3)4
EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	202	Physics	(4-2)4
		Total hours	(16-5)17

Summer

RS	200	Applied Radiological Health Physics	Summer of work experience

JUNIOR YEAR

First Semester

LL	209	Technical and Scientific Communication	(3-0)3
MA	301	Advanced Calculus for Applications	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
RS	401	Principles of Radiation Safety & Control	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-4)16

Second Semester

BI	462	Radiation Biology	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
RS	402	Principles of Radiation Safety & Control	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-7)17

Summer

RS	300	Applied Radiological Health Physics	Summer of work experience

SENIOR YEAR

First Semester

RS	411	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	431	Seminar in Radiological Sciences	(2-0)1
RS	451	Introduction to Electronic Product Radiation	(3-0)3
		General Elective	(3-0)3
		Elective	(3-0)3
		Total credit hours	12, 13 or 14

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
RS	412	Research in Radiological Sciences or Approved Technical Elective	2, 3 or 4
RS	432	Seminar in Radiological Sciences	(2-0)1
		General Elective	(3-0)3
		Elective	(3-0)3
		Total credit hours	12, 13 or 14

SUGGESTED TECHNICAL ELECTIVES

CN	521	Introduction to Environmental Studies	(3-0)3
RS	523	Air Resources Management	(3-0)3
RS	532	Air Sampling and Analysis	(1-6)3
MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
RS	422	Environmental Radiation & Nuclear Site Criteria	(3-0)3
RS	501	Radiation Physics and Shielding Design	(3-0)3
RS	503	Introduction to Radiation Chemistry	(3-0)3
RS	506	Radiation Dosimetry	(3-3)4
RS	507	Criticality and Nuclear Reactor Safety	(3-0)3

RADIOLOGICAL SCIENCES COURSE DESCRIPTIONS

RS 100 Basic Radiological Health Physics 4 weeks

[Primarily for RS students]

Introduction to atomic and nuclear physics; natural and artificial radioactivity, radiation, decay schemes; nuclear reactions including fisson and fusion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations; prin-

ciples of radiation detection and detection devices; counting systems and assay of α, β, γ emitters; survey and monitoring equipment; external radiation exposure and protection techniques; internal radiation exposure and protection techniques; radiation safety and control; accelerator and reactor health physics; medical radiation physics and X-ray protection.

RS 200 Applied Radiological Health Physics **Summer of work experience**
[Primarily for RS students]

Applied work experience during summer months as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 300 Applied Radiological Health Physics **Summer of work experience**
[Primarily for RS students]

Applied work experience during summer months as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 401 Principles of Radiation Safety and Control **(3-0)3**
[NU 202 or equivalent]

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material.

RS 402 Principles of Radiation Safety and Control **(3-3)4**
[NU 202 or equivalent]

A laboratory course giving students experience with equipment and practices of current use in the radiation protection field, an extension of RS 401 giving some of the practical aspects of radiation safety and control.

RS 411-412 Research in Radiological Sciences **8**
[Primarily for RS students]

A research problem related to the field of radiation protection is investigated by the student under the direction of faculty and staff of the Nuclear Center. The student will present a seminar on his research project. Areas of research anticipated in-

clude radiation shielding, radiation detection and measurement, radiation survey and monitoring, radiation biology, radiation chemistry, radiobiology, radiochemistry, radioecology, natural radioactivity, fall out, analyses and measurement of radioactivity and radiation levels associated with the operation of reactors and accelerators, and radioactive aerosols.

RS 422 Environmental Radiation and Nuclear Site Criteria (3-0)3

[Permission of Instructor]

Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, aquatic and terrestrial ecosystems; design and operation of environmental surveillance programs around nuclear facilities; reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations.

RS 431-432 Seminar in Radiological Sciences (2-0)2 (2-0)2

[Primarily for RS students]

Guest speakers and staff of the Nuclear Center present not only topics of current interest to the field of radiation protection but also descriptions of radiological health physics programs at various nuclear and radiation facilities. Students present a seminar either on their research project or on their critical essay.

RS 441 Radioisotope Techniques (3-3)4

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Integrated into both laboratory and lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities.

RS 451 Introduction to Electronic Product Radiation (3-0)3

[Permission of Instructor]

The theoretical and applied aspects of the generation, measurement, and uses of radiant energy from electronic products whose emissions span the entire electromagnetic spectrum; ultrasonic energy emitted by electronic products; biological effects, standards of protection and control, and consequences and intent of Public Law 90-602.

RS 501 Radiation Physics and Shielding Design (3-0)3
[Permission of Instructor]

Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding of point, surface, and volume sources; shielding design factors in reactor and accelerator operation.

RS 503 Introduction to Radiation Chemistry (3-0)3
[Permission of Instructor]

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination.

RS 506 Radiation Dosimetry (3-3)4
[Permission of Instructor]

Sources of radiation exposure; calculations of chronic and acute radiation doses and their effects; internal dosimetry including distribution and elimination of radioisotopes; alpha, beta, gamma, and neutron dosimetry; principles of charge measurement and energy transfer; use and calibration of instruments including solid state dosimeters, ion chambers, and extrapolation chambers.

RS 507 Criticality and Nuclear Reactor Safety (3-0)3
[Permission of Instructor]

Considerations of safe practices in transportation, storage, handling, and use of fissionable materials. Effects of moderators, reflectors, and geometrics in thermal, epi-thermal and fast assemblies. Natural and engineered safeguards are discussed.

RS 508 Environmental Toxicology and Epidemiology (3-0)3
[Permission of Instructor]

An investigation into the sources and transport of toxic components in our environment, studies of the effects of microorganisms in air and water, and the implications of industrial toxic wastes.

RS 523 Air Resources Management (3-0)3
[Permission of Instructor]

This course emphasizes the problems involved in air pollution and the technology developed for its control. Methods of

analysis and the technology for removing pollutants from waste gas streams are included. The course also includes comparative risks and benefits from the utilization of alternative energy resources with particular emphasis on comparisons between nuclear and conventional electrical power generating plants.

RS 532 Air Sampling and Analysis (1-6)3

[Permission of Instructor]

Methods for sampling and analysis of gaseous, particulate, liquid, and microbiological components in the ambient air and waste gas streams, including calibration of flow rate, volume measuring, and collection devices and the use of modern analysis techniques such as atomic absorption spectrophotometry, fluorescence analysis, and neutron activation.

COLLEGE
OF
EXTENSION AND
GENERAL STUDIES

COLLEGE OF EXTENSION AND GENERAL STUDIES

The College of Extension and General Studies is a group of departments, schools and programs which (except for the Evening School) do not offer curricula leading to a degree. They are support areas to the overall educational programs of the Institute. They are as follows:

Evening School

Continuing Education and Summer School

Department of Aerospace Studies

Department of Languages and Literature

Department of Physical Education

Department of Social Sciences

The Martin Luther King, Jr. Educational Opportunity Program

Libraries

Descriptions of the courses and programs offered, and other pertinent information about these schools, departments and programs are given in an appropriate location in the catalogue. The Evening School and Continuing Education and Summer School have separate catalogues describing their programs in greater detail.

DEPARTMENT OF AEROSPACE STUDIES

Instructional Staff

Head of Department

Robert E. Sizemore, Col., USAF, B.S.

Members

Bruce Baron, Capt., USAF, B.S. (Lowell Technological Institute), M.S. (Air Force Institute of Technology), Assistant Professor

Sebastian F. Coglitore, Capt., USAF, B.S. (Newark College of Engineering), M.S. (University of North Dakota), Assistant Professor

Charles D. L'Archevesque, Capt., USAF, B.A. (Syracuse University), M.A. (University of Colorado), Assistant Professor

Robert E. Sizemore, Col., USAF, B.S. (Mississippi State University), Head of Department and Professor

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men and women who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC), the first two college years, and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Four-Year AFROTC Program or the Two-Year AFROTC Program. Students electing the Four-Year Program will take the General Military Course during their freshman and sophomore years and the Professional Officer Course during their junior and senior years. They will attend four weeks of field training during the summer between the sophomore and junior years. As members of the program they are eligible to compete for AFROTC Scholarships. For acceptance into the POC, the Four-Year Program student must pass a physical examination, an Officer Qualification Test, and possess an acceptable academic rating. To qualify for enrollment in the Two-Year Program, students must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. They must also meet certain physical standards, pass an Officer Qualification Test, and possess an acceptable academic rating. Further, they must successfully complete a six-week Field Training Course before they can be accepted into the Professional Officer Course. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the Institute and the United States Air Force. Students in the Professional Officer Course receive a $100.00 per month subsistence allowance. Additionally, scholarships are available to a limited number of cadets in the program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. They serve on active duty in the Air Force in a specialty as close as possible to their academic training consistent with AF needs.

GENERAL MILITARY COURSE

FRESHMAN YEAR

First Semester

AS 101	U.S. Military Forces in the Contemporary World I	(1-1) 1

Second Semester

AS 102	U.S. Military Forces in the Contemporary World II	(1-1) 1

SOPHOMORE YEAR

First Semester

AS 201	U.S. Military Forces in the Contemporary World III	(1-1) 1

Second Semester

AS 202	U.S. Military Forces in the Contemporary World IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

First Semester

AS 301	Growth and Development of Aerospace Power I	(3-1) 3

Second Semester

AS 302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

First Semester

AS 401	The Professional Officer I	(3-1) 3

Second Semester

AS 402	The Professional Officer II	(3-1) 3

The AFROTC program is recognized as academic but of a highly specialized nature. It is not a requirement for graduation and students may not use more than six (6) credit hours of the

Professional Officer Course (junior and senior year subjects) in substitution for other subjects taken for graduation. Subjects taken in the ROTC program in the freshman and sophomore years are to be taken in addition to all other subjects listed in the various curricula. Academic credit is given for all ROTC subjects taken and passed and the grades will affect the student's academic rating. Unless otherwise specified in the section on each curriculum, the six credit hours of advanced ROTC may be elected instead of General Electives.

CORPS TRAINING

Corps Training is conducted one hour each week. It is an assembly of the entire cadet corps under the direction of the detachment officer staff. The General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to plan, organize and supervise cadet activities. During periods of inclement weather, Corps Training is conducted indoors and consists of programs to familiarize cadets with the life and work of Air Force officers and the base environment in which they function. Experts in the fields of Defense Policy and other current affairs subjects also lecture in the AFROTC Enrichment Program to broaden the student's appreciation in these areas.

FIELD TRAINING

Each cadet must attend field training during the summer before entry into the Professional Officer Course. Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $250.00 for the four-week Field Training and $400.00 for the six-week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot

training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of dual and solo flight instruction by a FAA certified civilian flying school at government expense.

CADET DECORATIONS AND AWARDS

A number of medals and awards are presented to selected cadets at special ceremonies held each semester. These awards include the Disabled American Veterans (DAV), the Costello Trophy, American Legion Excellence Awards, the Reserve Officer Association Medal, the LTI Trustees' and Alumni Awards.

In addition, the Department of Aerospace Studies confers several medals and awards, among them the Distinguished Military Cadet Award, for outstanding performance in various fields.

Distinguished AFROTC Graduate Awards, based on academic and military achievements, are given to outstanding graduates. These awards constitute an advantage in competing for a Regular Air Force commission.

AEROSPACE STUDIES

AS 101-102 U.S. Military Forces in the Contemporary World I and II (1-1) (1-1)2

An introductory course exploring the background, mission, and functions of U.S. Military Forces. Particular emphasis is placed upon the mission and organization of the US Air Force and the responsibilities of an Air Force officer. The course continues with an in-depth study of US strategic offenses and defensive forces and ends with an examination of the specific functions of US General Purpose and Aerospace Support Forces. This study will serve as a foundation for an introduction to the defense policy instruction offered in AS 201-202.

AS 201-202 U.S. Military Forces in the Contemporary World III and IV (1-1) (1-1)2

A brief study of defense policies as related to the strategies of the United States, the Soviet Union and China. The course continues with the study of defense organization, the role of the military in United States national policies and concludes with an examination of the factors involved in defense decision making.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the changing nature of military conflict; airpower in the United States; mission aand organization of the U.S. Air Force; Air Force concepts, doctrine and employment of aerospace power, including US space programs, vehicle, systems, and problems in space exploration. These areas are studied through the media of briefings, discussions, debates and written reports by the students to improve their communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership and introductory management principles. Classroom and organizational situations allow application of leadership and management skills, stress professional and personal responsibility and improve communicative skills through classroom discussions and student presentations.

ATHLETICS AND RECREATION

Athletics are a part of the total program at Lowell Tech, and essential to the overall development of the individual. New and extensive facilities and a competent professionally trained staff provide numberless opportunities for students to participate in a variety of activities.

A beautiful new, well-equipped physical education building includes a gymnasium, with a seating capacity of two thousand, an all-purpose gym of equal size to the main gymnasium, a collegiate-style swimming pool, a wrestling and judo room, weight training facilities, a gymnastics area, two handball and three squash courts, home and visiting team dressing rooms, a modern rifle range, and locker rooms for students and faculty with more than two thousand lockers available.

New athletic fields and a skating rink are located in the area adjacent to the physical education building.

An Intercollegiate Boathouse for L.T.I. is located on the Merrimack River in Lowell.

The Athletic Association is funded by student fees and provides extensive opportunities for student participation in Intercollegiate, Intramural and Recreation programs. All students are members of the Association and are admitted free to all home athletic contests.

Intercollegiate Athletics: Lowel Tech has intercollegiate competition in seventeen sports. Teams are scheduled in Soccer and Cross Country in the Fall; Basketball, Hockey, Wrestling, Gymnastics, Swimming, Skiing, Squash, Bowling and Rifle in the Winter; Baseball, Track, Golf, Tennis, Crew and Lacrosse in the Spring.

Intramurals: The intramural program at L.T.I. is extensive. The three leagues — Fraternity, Dormitory, and Independent — compete in the following activities: Touch Football, Basketball, Tennis, Golf, Bowling, Track, Cross Country, Ice Hockey, Speed Skating, Handball, Squash, Volleyball, Badminton, Water Basketball, Table Tennis, Six-Man Soccer, and Six-Man Lacrosse.

Recreation: The athletic facilities at L.T.I. are open for student use from 9:00 a.m. to 9:30 p.m. weekdays, and from 10:00 a.m. to 4:00 p.m. on Saturdays.

There are opportunities for student participation in the organized and informal recreational activities listed as follows: Badminton, Volleyball, Basketball, Physical Conditioning, Swimming, Diving, Water Basketball, Life Saving, Archery, Table Tennis, Touch Football, Skin and Scuba Diving, Wrestling, Judo, Karate, Rifle and Pistol Shooting, Weight Training, Gymnastics, Hand-

ball, Squash, Tennis, Ice Skating, Track and Field, Softball, and Lacrosse.

Equipment needed for most of these sports is available from the Issue Room on presentation of the student's ID card.

Students are urged to supplement their required activities with a regular program of recreation.

PHYSICAL EDUCATION

Instructional Staff

Head of Department

Raymond E. Sparks, B.S., M.A., P.E.D.

Director of Athletics

Waldo W. Yarnall, B.S.

Members

Richard M. Aronson, B.S. (Springfield College), M.Ed. (Boston University), C.A.S. (Springfield College), Assistant Professor

Robert T. Callary, B.S. (Springfield College), M.Ed. (Fitchburg State College), Instructor

A. Grant Carrow, A.B. (University of New Hampshire), Instructor

George E. Davis, B.Ed. (Plymouth State College), Athletic Coach and Physical Education Instructor

A. James Oliver, B.S. (Boston University), M.Ed. (Boston State College), Associate Professor

William J. Riley, Jr., B.S. (Boston University), Instructor

Raymond E. Sparks, B.S. (Indiana State University), M.A. (Columbia University), P.E.D. (Springfield College), Head of Department and Professor

James E. Stone, B.S. (Springfield College), Assistant Professor

Waldo W. Yarnall, B.S. (University of Vermont), Director of Athletics

Physical education makes its contribution to the total college curriculum through specific programs of conditioning exercises, self-testing activities, sports, recreational games, gymnastics, rhythms, aquatic activities, and personal defense activities such as wrestling, judo, and karate. Physical Fitness testing is included as a basic part of the program. The students are expected to become familiar with and develop efficiency in a variety of activities especially team games, individual recreational sports, swimming, and physical fitness.

The classes meet twice a week and are required for the Freshmen. Lowell Tech students must pass a swimming test and four quarters of Physical Education. Each quarter is half a semester. Students who satisfy minimum requirements in the swimming and the Physical Fitness Test are allowed to choose any activity which the Department offers. A new activity must be chosen each quarter.

Students who do not satisfy the minimum requirements are assigned a swimming or a Physical Fitness class. At the end of the quarter, these students are retested.

The program is elective for sophomores, juniors, and seniors. After completing the freshman requirement, they may choose those activities which they wish to receive additional instruction. Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, physical education credit will be given for such participation.

The following objectives serve as guides for the entire program:

1. The improvement of health through increased organic vigor.
2. The development of efficient and effective sports-skills and motor fitness.
3. The development of desirable social attitudes and standards of conduct.
4. The development of an appreciation for an interest in physical activities which will result in continued participation in wholesome and enjoyable leisure pursuits.

I INDIVIDUAL ACTIVITIES

P.E. 110	Physical Fitness
P.E. 112	Golf
P.E. 115	Individual Sports (handball-squash-paddle racquets)
P.E. 116	Tennis
P.E. 117	Archery
P.E. 120	Weight Training
P.E. 125	Gymnastics
P.E. 126	Badminton
P.E. 127	Fencing

II TEAM ACTIVITIES

P.E. 130	Basketball
P.E. 135	Hockey
P.E. 136	Skating
P.E. 140	Soccer
P.E. 145	Softball
P.E. 150	Touch Football
P.E. 155	Volleyball
P.E. 156	Indoor Team Games

III AQUATICS

P.E. 160	Swimming for Beginners
P.E. 161	Intermediate Swimming
P.E. 162	Pre Life-saving

P.E. 163	Life-saving
P.E. 164	Competitive Swimming
P.E. 165	Competitive Diving
P.E. 166	Water Basketball
P.E. 167	Water Polo
P.E. 168	Advanced Diving
P.E. 230	Scuba and Skin Diving

IV COMBATITIVES

P.E. 170	Judo
P.E. 172	Karate
P.E. 175	Wrestling

V INTERCOLLEGIATE SPORTS

P.E. 400	Baseball
P.E. 405	Basketball
P.E. 470	Bowling
P.E. 200	Crew
P.E. 428	Cross Country
P.E. 410	Golf
P.E. 432	Gymnastics
P.E. 415	Hockey
P.E. 460	Lacrosse
P.E. 320	Riflery
P.E. 425	Soccer
P.E. 420	Skiing
P.E. 340	Squash
P.E. 465	Swimming
P.E. 430	Tennis
P.E. 320	Track
P.E. 435	Wrestling

DEPARTMENT OF LANGUAGES AND LITERATURE

Instructional Staff

Head of Department

Howard K. Moore, A.B., A.M., M.L.S., Ph.D.

Members

William M. Aiken, B.A. (Trinity College), A.M. (Harvard University), Assistant Professor

Howard C. Arnold, A.B. (Oberlin College), M.Ed. Northeastern University), Assistant Professor

Donald R. Berry, B.A., M.A. (Baylor University), Assistant Professor

Andrea Broderick, B.A. (University of New Hampshire), M.A. (Vanderbilt University), Instructor

William F. Coughlin, Jr., B.S. (Lowell State College), A.M. (Middlebury College), Instructor

Arthur T. Dabilis, A.B. (Suffolk University), M.A. (Northeastern University), Instructor

Robert J. DeYoung, B.A., M.A. (New York University), Assistant Professor

Richard R. Forster, B.A. (Louisiana State University), M.A. (University of Southern California), Instructor

William R. Hersey, B.S. (Lowell State College), M.A. (Boston College), Instructor

Lester B. Hudson, A.B., M.A. (Boston University), Instructor

Charles E. Jarvis, B.S., M.A. (Boston University), Professor

Marianne H. Knowlton, B.A. (Smith College), M.A. (Tufts University), Assistant Professor

John J. McCaffrey, A.B. (Suffolk University), A.M. (Tufts University), Assistant Professor

Barbara Miliaras, A.B., Ed.M. (Boston University), Instructor

Howard K. Moore, A.B., A.M. (Boston University), M.L.S. (Simmons College), Ph.D. (Boston University), Head of Department and Professor

William L. Mulcahy, Jr., B.A. (Harvard University), M.Ed. (Salem State College), Instructor

Cornelius P. Murphy, B.S., M.A. (Boston College), M.Ed. (Salem State College), Instructor

Gerard W. O'Connor, A.B. (Harvard University), A.M., Ph.D. (Boston University), Professor

John J. Riley, A.B., M.A. (Boston University), Assistant Professor

Charles J. Ryan, B.A. (University of Connecticut), M.A. (University of Massachusetts), Instructor

Anthony C. Turrisi, B.S. (Massachusetts Institute of Technology), M.A. (University of Wisconsin), Instructor

Robert J. Whelan, B.S. (Boston College), M.A. (Catholic University of America), Assistant Professor

Roger E. Wiehe, B.A. (Yale University), M.A. (University of Illinois), Ph.D. (Columbia University), Professor

LANGUAGES AND LITERATURE

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 207 Oral Business Communication (3-0)3
[LL 111-112]

Techniques and ethics of oral presentation. Panels, discussions, and problems. Frequent use of language laboratory. Limited to fifteen students.

LL 209 Technical and Scientific Communication (3-0)3
[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature: to 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature: from 1865 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature: (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature: from 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature from 1798.

LL 218 Afro-American Literature (3-0)3
[LL 111-112]

A study of poems, plays, short stories and novels by Negro-Americans from 1920 to the present, including Langston Hughes, Richard Wright, James Baldwin, Ralph Ellison, and others.

LL 219 The Film in Communication (3-0)3
[LL 111-112]

The film as a medium for communication. Historical evolution of screen conventions. Emphasis on analysis and evaluation of film.

LL 221 Educational Broadcasting Philosophy Laboratory (1-6)3
[Permission of Instructor]

Practical aspects of educational, community-oriented programming.

LL 222 Educational Broadcasting Philosophy (2-2)3
[Permission of Instructor]

Objectives which may be set for various types of broadcast stations, and the formulation of plans to achieve these objectives. Station management and operations in each type of station with emphasis on student-run educational stations. The art of announcing and program development. Discussion of F.C.C. policy relative to educational broadcast stations.

LL 224 Literary Criticism for the Technology Major (3-0)3
[LL 111-112]

Familiarizes the student with the biographical, psychological, sociological, and analytical approaches to literature. Application to works by Poe, Crane, Hemingway, Camus, and others.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 235 English Drama After Shakespeare (3-0)3
[LL 111-112]

A study of main trends in English dramatic literature from 1600 to the present: comedy of humors, comedy of manners, heroic tragedy, sentimental comedy, satire, problem play, theatre of the absurd. Readings will include representative work of Ben Jonson, Congreve, Dryden, Goldsmith, Sheridan, Shaw, Samuel Beckett, and others.

LL 238 Science and Literature (3-0)3
[LL 111-112]

A study of primarily literary works with scientific subject matter. Major topics include (1) the scientist as hero, (2) aesthetic implications of scientific discoveries, (3) the controversy over the "two cultures." Wide range of readings from Lucretius to Brecht's **Galileo.** [Not a course in science fiction.]

LL 259-260 Elementary German (3-0) (3-0)6

Fundamentals of grammar and basic vocabulary. Audio-lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use. No credit for the first semester without the second.

LL 261-262 Elementary Technical German (3-0) (3-0)6

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. No credit for the first semester without the second.

LL 263-264 Elementary French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. For students who have had less than two years of secondary school training in French. No credit for the first semester without the second.

LL 265-266 Elementary Russian (3-0) (3-0)6

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use. No credit for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing skills in reading and writing. No credit for the first semester without the second.

LL 269 Literature of the Beats (3-0)3
[LL 111-112]

A study of the Beat writers of the 1950's and 1960's: Kerouac, Ginsberg, Burroughs, Corso, Ferlinghetti, and two or three others. An examination of the Beat Rebellion and its influence on the American scene today. Resources: tapes, letters, guest speakers, and other primary sources.

LL 309 Woman in Modern Fiction (3-0)3
[LL 111-112]

A study of the changing role of women in our society as viewed and recorded by the literary artist. The study will extend from Thomas Hardy and D.H. Lawrence to the present, and concentrate finally on the current Liberation movement.

LL 311 Creative Writing and Advanced Composition (3-0)3
[LL 111-112]

A course designed to develop the student's natural ability in verbal expression. Original works of short fiction, poetry, and exposition will be presented and discussed at regular intervals throughout the term.

LL 313 Introduction to Continental Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 315 Myth and Symbol in Literature (3-0)3
[LL 111-112]

An examination of the use of myth and symbol in modern literature for its thematic and cultural-historical significance. Emphasis on the analysis literature selected from the works of Dostoevski, Gide, Mann, Conrad, D.H. Lawrence and others.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 318 The Evolution of the Existential Hero (3-0)3
[LL 111-112]

The development of the alienated hero in fiction from Stendhal, and Camus with emphasis upon the works of the following authors: Stendhal; Melville; Dostoevski; Gide; Sartre; Camus; Hemingway and Beckett.

LL 319-320 The Image of Man in Western Thought (3-0) (3-0)6
[LL 111-112]

The first semester is not a prerequisite to the second. Examination of the major ideas and cultural influences in Western Thought from the fall of Rome to the present as reflected in literature, the visual arts and music.
Semester I: The Latin Middle Ages to the French Revolution
Semester II: The Industrial and Scientific Revolution to the Emergence of the Absurd.

LL 333 Problems of Philosophy (3-0)3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 335 The Southern Renaissance in American Literature (3-0)3
[LL 111-112]

An investigation of universal implications in "regional" literature: Faulkner, Flannery O'Connor, Robert Penn Warren, Eudora Welty, James Agee, William Styron, Ralph Ellison, Truman Capote, James Baldwin.

LL 341 Satire (3-0)3
[LL 111-112]

A study of a literary genre. Selected readings from Horace and Juvenal through Orwell and Burgess.

LL 342 Utopian Literature (3-0)3
[LL 111-112]

A study of utopias from Plato through Bacon to Bellamy, Wells, and Clarke.

LL 344 — Modern American Poetry — (3-0)3
[LL 111-112]

An inductive investigation into recent trends in American verse, using the work of Frost, Pound, Eliot, and Williams as instructive points of departure and culminating in student investigation and individual poets of special interest.

LL 345 — Modern Irish Literature — (3-0)3
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 — Intermediate French — (3-0) (3-0)6
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit. No credit for the first semester without the second.

LL 365-366 — Intermediate Literary and Conversational Russian — (3-0) (3-0)6
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records. No credit for the first semester without the second.

LL 367-368 — Intermediate German — (3-0) (3-0)6
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idiomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of significant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use. No credit for the first semester without the second.

LL 369-370 — Intermediate Spanish — (3-0) (3-0)6
[LL 268 or equivalent]

Intensified study of the language, with increased opportunity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings

as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits. No credit for the first semester without the second.

LL 431 Philosophy of Science (3-0)3
[LL 111-112]

Consideration of the hypothetico-inductive method of gaining knowledge, the significance of causality and its problems, the principles of induction, empiricism, relations between physical and biological sciences, logical models for scientific discovery. Historical examples will be used.

LL 435 English Literature of the Eighteenth Century (3-0)3
[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectual background.

LL 436 English Romantic Poets (3-0)3
[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

LL 443 Science Fiction (3-0)3
[LL 111-112]

A study of major works in science fiction and fantasy from Wells and Tolkien through Heinlein and Delaney. Emphasis is literary and historical.

LL 444 Popular Culture (3-0)3
[LL 111-112]

A study of the Hero in American popular culture. Selected heroes include the Cowboy, the Tough Guy, the Secret Agent, the Politician, the Black, and the Musician. Movies, records, magazines, TV, and popular literature will be used.

LL 467 Seminars in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3
[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 Nineteenth-Century British Novel (3-0)3
[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 481 Classical Literature (3-0)3
[LL 111-112]

An examination of the contributions of the Greeks to our literary culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

LL 482 The Short Story (3-0)3
[LL 111-112]

A critical survey of the growth and development of the short story. Consideration of the works of key writers in this genre.

LL 495-496 Reading and Research 6
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideraton for admission limited to Juniors and Seniors with "B" average.

LL 961 British Literature (3-0)3

[For students in Engineering Technology only]

An introduction to British Literature from the Anglo-Saxon Period to the Contemporary Period, with emphasis on major authors and key periods.

LL 962 American Literature (3-0)3

[For students in Engineering Technology only]

An introduction to the literature of the United States from the Colonial Period to the Contemporary Period, with emphasis on major authors and historical background.

DEPARTMENT OF SOCIAL SCIENCES

Instructional Staff

Head of Department

Francis R. Walsh, B.S., M.A., Ph.D.

Members

Stanley J. Chase, A.B., M.A. (Siena College), Assistant Professor

William S. Harrison, A.B. (Harvard University), Assistant Professor

Jonathan J. Liebowitz, A.B. (Columbia University), M.A., Ph.D. (University of California, Berkeley), Assistant Professor

Joseph W. Lipchitz, B.A., M.A. (University of Massachusetts), Ph.D. (Case Western Reserve University), Associate Professor

William G. Nowlin, Jr., B.A. (Tufts University), M.A. (University of Chicago), Instructor

Miriam D. Price, A.B. (Smith College), Instructor

Francis R. Walsh, B.S., M.A., Ph.D. (Boston University), Head of Department and Professor

Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston University), Assistant Professor

SOCIAL SCIENCES

SS 223 The United States: 1865-1917 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

SS 224 The United States: 1918-1945 (3-0)3

A study of politics and foreign policy from Wilson through Roosevelt.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 226 Europe: 1914 to the Present (3-0)3

A study of the period of the two World Wars and the postwar periods in which totalitarianism, new power alignments, and new international organizations developed.

SS 232 Social and Economic Change in Europe: 1750 to the Present (3-Q)3

This course studies the impact of economic change on the life of Europe since the 18th century. After a brief survey of theories of development, the economic revolutions of the past 200 years are examined in depth. The relationships between economic change and social and intellectual life are also explored.

SS 235 England: Roman Times to the Restoration (3-0)3

The history of England to 1660, with emphasis on the development of the institutions of monarchy and Parliament, culminating in the clash between the two and the Restoration in 1660.

SS 236 England: The Restoration to the Present (3-0)3

England's history from the Restoration, tracing the rise of parliamentary government, the cabinet system, domestic reforms, and imperial policy.

SS 238 Revolutions in European History (3-0)3

An analysis of the causes and effects of the English, French and Russian Revolutions, with some comparisons to revolutions outside of Europe. The role of revolution in European political and social development.

SS 240 European Urban History (3-0)3

The origins of the city. Changing structure and function of cities in Ancient, Medieval and Early Modern Europe. The industrial city and the city of the future.

SS 242 European Imperialism (3-0)3

The doctrine and practices of European expansion in the 19th century. Economic and political interpretations. The reactions of subject peoples and liberation movements.

SS 301 Government of the United States (3-0)3

This course focuses on contemporary social and political factors in the United States. Readings, discussion, and analysis are used to gain an understanding of the structural and behavioral realities of modern American politics.

SS 303 Psychology (3-0)3

An introduction to the basic principles of human behavior. The major areas covered include the origins and development of psychology as a science, the stages of human development, motivation and emotion, sensing and perceiving, the nature of neuroses and psychoses.

SS 305 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 307 Seminar in Small Group Analysis (3-0)3

Experimental exploration of group processes. Members of seminar engage in the task of simultaneously building a group and analyzing group structure and process, applying relevant social psychological theory and principles.

SS 308 Psychology of Interpersonal Behavior (3-0)3

A study of the science of interpersonal behavior and of the development of theories of the personality. Major topic areas discussed include: the meaning and measurement of interpersonal behavior, behavior development, personality development, conflict and anxiety, defense and coping mechanisms.

SS 310 Contemporary Social Problems (3-0)3

This course deals with a series of contemporary social issues such as minority problems, violence, and population.

SS 315 Sociology of Deviance (3-0)3

Examination of the concept of deviance in sociology and its implications for the study of contemporary social behavior. The application of this concept to the study of mental health, alcoholism, drug addiction, and crime.

SS 320 Urban Sociology (3-0)3

Development of urban communities. Factors in city growth. Ecology of cities. Social organization of modern communities and metropolitan regions.

SS 322 Moral Problems in a Technological Age (3-0)3

The course will deal with contemporary social issues such as, war and peace, prejudice and race relations, inter-faith tensions, changing sexual patterns, and ecology.

SS 335 American Economic History (3-0)3

A study of the growth and development of the American economy from its European origins to the present.

SS 340 The United States: 1945 to the Present (3-0)3

An historical study of the United States since World War II.

SS 352 Contemporary Political Theory (3-0)3

An examination of contemporary political theory and its relation to current social problems.

SS 360 Government of China (3-0)3

An in-depth study of the politics of the Chinese People's Republic, including its history, ideology, internal politics, and foreign policy.

SS 362 Social Psychology (3-0)3

A seminar involving the problem of social order, the socialization process, social interaction, and the maintenance of social order.

SS 401 Afro-American History (3-0)3

An historical study of the patterns of racial relations and the participation of Afro-Americans in the social, economic, political, and cultural life of the United States. The topics covered include the origins and development of the slave system, the Civil War and Reconstruction, urbanization, the Civil Rights movement, and "Black Power."

SS 404 Technology and Social Change I (3-0)3

An examination of the impact of technology on contemporary man and society. Topics include the military-industrial complex, technological elites, and the role of the engineer.

SS 405 Technology and Social Change II (3-0)3

A continuation of SS 405. Topics include the impact of technology, politics, education, and the critics of technology.

SS 406 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles" — the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 407 The Technological Future: The Social and Political Aspects (3-0)3

Lectures and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 410 History of Science and Technology (3-0)3

Science from the Middle Ages to the present. The scientific revolution of Copernicus, Galileo and Newton. Biology, evolution, relativity and 20th century science. Relationship of science to technology and both to society.

SS 451 History of France (3-0)3

The History of the development of ideas and institutions in modern France from the age of absolutism through the mid-twentieth century.

SS 452 Seminar in Recent American History (3-0)3

A study of selected problems in American History.

SS 453 Seminar in Modern European History (3-0)3

A study of selected problems in Modern European History.

SS 454 Seminar in Political Science (3-0)3

A study of selected problems in Political Science.

SS 455 Seminar in Psychology (3-0)3

A study of current trends in Psychology.

SS 456 Seminar in Sociology (3-0)3

A study of current trends in Sociology.

SS 460 Elements of Urban Affairs (3-0)3

Survey of the field of urban affairs including housing, intergovernmental relations, transportation, human resources, and the urban environment.

SS 461 Studies in Regional and Metropolitan Development (3-0)3

Examines interrelationships between economic, social land use and transportation planning at the regional and metropolitan levels.

SS 462 Urban Reform (3-0)3

An examination of the alternatives in urban reform. Topics to be covered include social welfare programs, urban renewal, and planned cities.

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles

have been applied by the United States are examined through case studies.

SS 472 National Security Policy (3-0)3

A study of the relationship of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of natural security.

SS 474 Cultural Anthropology (3-0)3

A seminar analyzing various living societies and their cultures in terms of social adjustment to recurring needs.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U. S. S. R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviet state; the Stalinist period; and current domestic and foreign problems.

SS 482 The United States: Urban History (3-0)3

Social, cultural, economic, and political factors in the formation and development of the modern American city.

SS 483 The Development of Western Civilization: To 1453 (3-0)3

The history of the development of ideas and institutions from democratic Athens to the renaissance.

SS 484 The Development of Western Civilization: Since 1453 (3-0)3

The development of ideas and institutions from the renaissance to the mid-twentieth century.

SS 485 Comparative World Governments (3-0)3

A study of comparative politics concentrating on Europe and the Third World. Emphasis will be given normally to England, France, the Federal Republic of Germany, the Soviet Union, China, and India. The analysis of these countries will include discussions of national character, history, the social and economic structure, and the political arrangements within each country.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 489 Political Parties in the United States (3-0)3

A study of voting behavior, policy making, and the historical development of American political parties.

SS 497 Tutorial in the Social Sciences (3-0)3

Individual directed study under the guidance of individual members of the department.

SS 528 Social Ecology (3-0)3

This course provides the student with an exposure to man's interrelationship with his total environment and its effects on social behavior.

LOWELL TECHNOLOGICAL INSTITUTE
LOWELL MASSACHUSETTS

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ULLETIN of THE
OWELL TECHNOLOGICAL
STITUTE

73-1974

DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Dean of Admissions
Scholarship aid	Director of Financial Aid
Official transcripts	Registrar
Graduate studies	Dean of Graduate School
Summer school	Director of Summer School
Evening study program	Director of the Evening School
Alumni affairs	Alumni Office
Graduate placement	Placement Director
Library industrial corporate membership	Librarian
Conferences, special programs, public relations	Director of Public Relations
Sponsored research	Lowell Technological Institute Research Foundation

Anne Marie Ferguson

LOWELL TECHNOLOGICAL INSTITUTE

1973-1974 CATALOGUE

Bulletin

of

Lowell Technological Institute

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Equal Opportunity Policy

Lowell Technological Institute is committed to a policy of providing equal opportunity for all. In all matters involving admission, registration, and all official relationships with students, including evaluation of academic performance, the Institute maintains a policy of non-discrimination. Lowell Tech is also an equal opportunity employer; it is institutional policy that there shall not be any discrimination against any employee or applicant for employment because of race, color, religion, sex, age or national origin.

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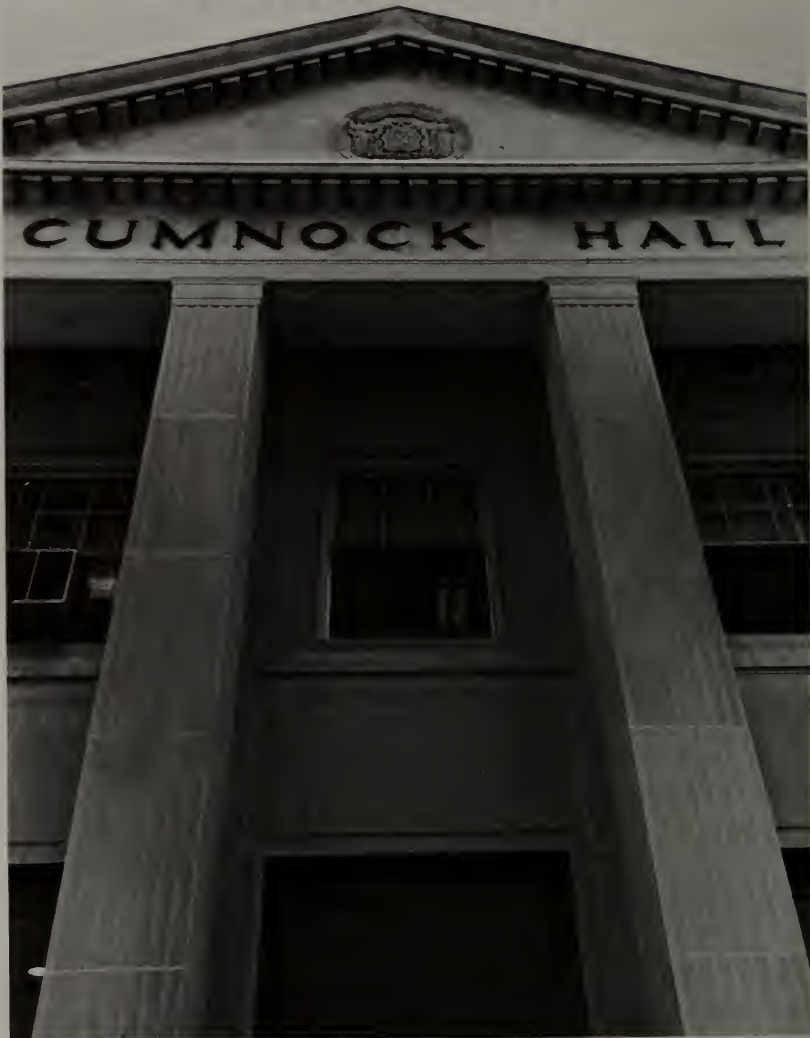
CUMNOCK HALL

LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

Day program leading to B.S., B.S. in B.A., B.S.I.T., M.S., M.M.S., M.M.T., and Ph.D. degrees

Evening programs leading to A.B.A., A.S., A.E.T., A.T., B.B.A., B.S.T., B.S.E.T., and B.T. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineer's Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

Total enrollment — 8258
Undergraduate Colleges — 3269
Evening School — 2900
Summer School — 1575
Graduate School — 514

Men and women students from 20 states and 30 countries

Tuition: $200 for U.S. citizens who are residents of Massachusetts; $600 for all others

L.T.I. Research Foundation conducts research and development work for government and industry

The main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River one half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 a.m. — 5:00 p.m., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

* * *

The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein, and to change any of the subjects or curricula, or portions thereof, without prior notice.

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ACADEMIC CALENDAR, 1973-1974

First Semester

August 27, Monday	Graduate student diagnostic testing begins
August 30, Thursday	Transfer and graduate students register
August 31, Friday	Sophomore and graduate students register
September 3, Monday	Institute closed (Labor Day)
September 4, Tuesday	Junior, senior and graduate students register
September 5, Wednesday	Freshman students register
September 5, Wednesday	Classes begin for upperclassmen and graduate students
September 6, Thursday	Classes begin for freshman
September 21, Friday	Last day to register for new subjects
October 8, Monday	Institute closed (Columbus Day)
October 10, Wednesday	Monday schedule of classes
October 22, Monday	Institute closed (Veterans Day)
November 21, Wednesday, 6 p.m.	Thanksgiving Recess begins
November 26, Monday	Classes resume (Last day to drop courses without academic penalty)
December 14, Friday	Classes end
December 15, Saturday	Examinations begin
December 21, Friday	Semester ends

Second Semester

January 14 and 15 Monday and Tuesday	Registration of Students (graduate and undergraduate)
January 16, Wednesday	Classes begin
February 1, Friday	Last day to register for new subjects
February 18, Monday	Institute closed (Washington's Birthday)
March 8, Friday, 6 p.m.	Spring Recess begins
March 18, Monday	Classes resume
April 12, Friday	Good Friday Recess (no classes)
April 15, Monday	Institute closed (Patriots Day)
April 17, Wednesday	Monday schedule of classes
Aprill 22, Monday	Last day to drop courses without
May 1, Wednesday	academic penalty
May 8, Wednesday	Spring Carnival (no classes)
May 9-10,	Classes end
Thursday-Friday	Reading Period
May 11, Saturday	
May 17, Friday	Examinations begin
May 26, Sunday	Semester ends
	Commencement

Normally, classes are held from 8 a.m. to 6 p.m., Monday through Friday. This calendar is subject to change.

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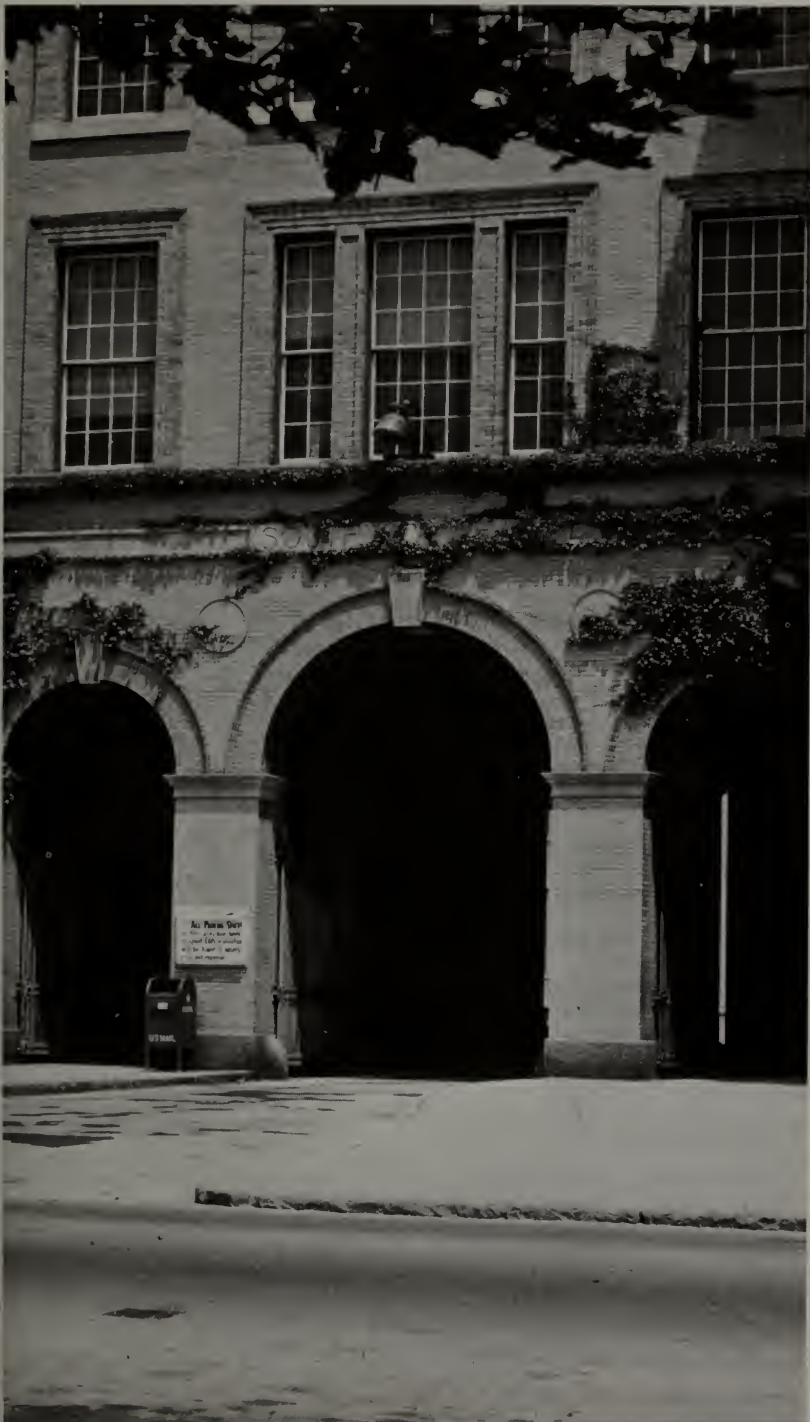

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GENERAL INFORMATION

History and Aims

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry. In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, radiological science, physics, mathematics, nuclear engineering, industrial management, business administration, meteorology, and biological sciences. In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to Lowell Technological Institute. The Institute grants Bachelor of Science, Master of Science, Master of Management Science, Master of Mathematics for Teachers, and Doctor of Philosophy degrees. Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

The major aims of Lowell Technological Institute are to furnish sound educational programs in science, engineering, technology, business and management at both the undergraduate and graduate levels to cultivate in its students a professional attitude in their fields of concentration and to develop their ability for creative thinking. All education, and particularly in the fields of study offered at the Institute, must be based on a thorough grounding in the fundamentals upon which the study in the area of specialization is built; but, it must prepare the student for life in general and thus there must be an emphasis on the development of self-reliance and awareness of the interrelation between science, technology and industry and the society in which we live. For this reason, all curricula have a balance of basic material leading into more advanced theoretical and applied treatment of this knowledge with the inclusion of sufficient humanities to make a meaningful education for a productive life. Graduates are prepared to enter industry in the fields they have chosen or to continue for further education in graduate schools in preparation for research, teaching, or industrial positions.

Accreditation

The Institute is a member of the New England Association of Schools and Colleges. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in chemical, electrical, mechanical, and textile engineering. The ECPD has also accredited a two-year part-time program in civil engineering technology and a four-year part-time program in civil engineering technology. The chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. The Institute is co-educational.

Campus

The campus is situated 25 miles north of Boston, on the banks of the Merrimack River in Lowell, a city of 100,000 long famous as a textile center and more recently for its increasingly diversified industries. The 60 acre campus includes 19 main buildings, among them a large modern library, a nuclear center, and a fine physical education facility with an olympic size swimming pool. Ready for occupancy in September 1973 are a new hi-rise student union-dormitory complex, an arts and science building and a chemistry-physics building. Scheduled for construction is a new parking area for 1500 cars.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $20,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, and a Control Data Corporation's 3100 computer.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Dean of Admissions Office has received senior grades for this period. The responsibility of having these grades forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure no less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Dean of Admissions, Lowell Technological Institute, Lowell, Mass. 01854.

Applications for admission are preferred by the Institute on or before April 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is requesting financial assistance must file a Parents' Confidential Statement with the Institute.

Application Procedure

A candidate for admission to Lowell Technological Institute in any of the fields of study open to undergraduates must:

1. Complete the first two pages of the admissions application form and the attached STUDENT DATA SHEET.
2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.
3. Submit the entire application form to the office of the secondary-school principal or guidance director with a request that the office fill out the remainder of the application form and mail it directly to the Dean of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the SAT Test during the period of April of the Junior year through March of the Senior year in secondary school. Letters, telephone calls, etc., will not be accepted in place of the official score card.

6. Applicants must indicate their chosen major field of study in the proper space provided on pages 1 and 5 of the application.

7. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

8. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

9. The Institute requires the prepayment of 50% of the first semester's tuition within 12 days of the date upon which the applicant is accepted. For Massachusetts residents this amounts to $50.00. The prepayment is refundable if the student notifies the Office of Dean of Admissions in writing on or before June 1, that he does not intend to enroll. Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving a final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation. The responsibility for sending this final transcript to the Dean of Admissions Office rests with the student. Failure to instruct his secondary school to forward this final transcript could result in his being not accepted in the fall.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus Days. Personnel from the Dean of Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on October 26, 1973, January 25, 1974, and March 8, 1974 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must have been enrolled in a college preparatory program and must be a graduate of a secondary school approved by the New England Association of Colleges and Secondary Schools, Inc., the Regents of the State of New York or a board of equal standing.

The New England Association of Colleges and Secondary Schools accredits schools and colleges in the six New England states. Membership in one of the six regional accrediting associations in the United States indicates that the school or college has been carefully evaluated and found to meet standards agreed upon by qualified educators. Colleges support the efforts of public school and community officials to have their secondary school meet the standards of membership.

2. For all courses except Business Administration and Industrial Technology a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiencies in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration and Industrial Technology a candidate must have completed 16 units of approved high school work:

English	4 units
mathematics	2 units
American history and social studies	2 units
laboratory science	1 unit
electives	7 units

Advanced Placement

Lowell Technological Institute subscribes to the Advanced Placement Program of the College Entrance Examination Board which provides academic credit and placement for students who qualify. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

College-Level Examination Program

Lowell Technological Institute recognizes the College-Level Examination Program (CLEP) for both placement and credit. This placement and credit is awarded in both the general CLEP examination and the subject CLEP examination. The amount and level of credit given for both exams is determined by the Dean of the College and the Dean of Admissions.

Information concerning the subject examination, general examination and tests should be directed to the College-Level Examination Program, Box 1821, Princeton, N.J.

Students from Other Countries

All foreign applicants for whom English is a second language and who have not completed two years of English in United States schools must take an English Proficiency Test, and have results sent to the Dean of Admissions, Lowell Technological Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U.S.A. and, as stated above, request the results be sent to Lowell Technological Institute.

The **TOEFL Bulletin of Information** and Registration Form can be obtained in a number of cities outside the United States. They often are available at one of the following: American Embassies and Consulates, Offices of the United States Information Service (USIS), United States Educational Commissions and Foundations abroad, and Binational Centers. In addition, several private organizations distribute TOEFL bulletins, among them (1) the Institute for International Education (IIE) in Nairobi, Kenya; Kowloon, Hong Kong, Paris, France; and Lima, Peru, (2) the African-American Institute in Dar es Salaam, Tanzania; and Lagos, Nigeria, (3) the American Friends of the Middle East in Tehran, Iran; Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt, (4) the American-Korean Foundation in Seoul, Korea, and (5) the Bureau of Educational Research at Ewing Christian College, Allahabad, U.P. India.

Students who cannot obtain a TOEFL bulletin and registration form locally should write well in advance for them to: Test of English as a Foreign Language, Box 899, Princeton, New Jersey 08540, U.S.A. Students residing in Taiwan must apply to: Lan-

guage Center, 2-1 Hsu-chow Road, Taipei, Taiwan (100), for the Special Taiwan editions of TOEFL publications.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that required of U.S. citizens. They are urged, however, to have the transcript of their secondary school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U.S. students.

Transfer Credit Guidelines

A. A prospective student who wishes transfer to Lowell Technological Institute must indicate the curriculum major he intends to pursue. Because of space requirements, Lowell Technological Institute reserves the right to limit assignment of transfers to specific curricula.

B. A student must place on file the following credentials:

1. Transfer application completed.
2. Letter of recommendation from transferring Institutions.
3. High School record.
4. College transcript (all colleges attended).
5. TOEFL (if required).
6. S.A.T. (if required).
7. Specific listing of all subjects not shown on available transcripts.

C. Completed application forms are considered by the Committee on Admissions. Selection of potential transfer credit students is based entirely on its determination.

D. Transfer preferred application deadlines are as follows:

(A) Spring: Application by November 15. Completed materials January 1st.

(B) Fall: Application by May 1st. Completed materials July 1st.

E. Credit will not normally be considered in subjects where applicant's grade is lower than "C" range.

F. A student should complete a minimum of one-year (2 semesters; 3 trimesters) at an approved Junior College, Technical Institute or 4 year College.

G. The applicant should have an academic cum average of 2.00 or above in order to qualify for a transfer status.

H. A College, in order to qualify for transfer status, should offer at least the Associate Degree.

I. Students completing the equivalent of one full year of college work, the S.A.T. Examination requirement is waived.

J. One full year of Physical Education completed at another Institute will be considered for transfer credit. This subject is a degree requirement at L.T.I.

K. The following are the Credit requirements for Academic Classifications:

Freshman	0 to 23 Credits
Sophomore	24 to 55 Credits
Junior	56 Credits

It should be noted that the classification of Sophomore or Junior does not remove the course requirement of the preceding classification. Example: A student with 58 credits and classified as a Junior may be required to take Freshman Chemistry if he has not taken it or has not received credit for it.

NOTE:

International Students are advised that unless they have completed two years of college level work in the United States at an accredited College or University, they must fulfill the CEEB, S.A.T.'s and the TOEFL requirements.

Students who are not U.S. citizens and who are not immigrants, must obtain permission from U.S. Immigration and Naturalization Service to transfer from one educational institution to another. Permission should be obtained AFTER receiving admission as a transfer student.

GED Certificate

In order to encourage and support non high school graduates in their effort to obtain a college education, Lowell Technological Institute recognizes the GED TEST as an instrument to obtain the Massachusetts High School Equivalency Certificate which we in turn honor in lieu of a high school diploma. This applies to applicants from the state of Massachusetts only, and students applying from other states should consult their Department of Education regarding how the GED Certificate is used as an equivalent to a high school diploma.

New England Regional Student Program (N.E.R.S.P.)

Students who are legal residents of any one of the other five New England States may be eligible for consideration under this program. State Universities in New England offer certain undergraduate curricula to students from other New England States who cannot obtain a particular curriculum at their own State University. See your high school Guidance Counselor or write to

the New England Board of Higher Education, 20 Walnut Street, Wellesley, Mass. 02181, or the Dean of Admissions, Lowell Technological Institute for further details.

Civil Rights Compliance

Lowell Technological Institute adheres to the terms of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) entitled "Nondiscrimination in Federally Assisted Programs," which states:

"No person in the United States shall, on the ground of race, color or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

STUDENT UNION

The eighteen story Student Union - High Rise Dormitory complex will officially open in September of this year. The building will offer many varied facilities and will become the focal point of student activities at L.T.I.

The first six floors contain the student activities area which feature a rathskeller, a game room, meeting and conference rooms, and lounge areas. There is also a 700 seat dining hall which can be converted into a dance area for recreational use. For the more academically minded, the Union contains a drawing room and work area, a music appreciation room and a calculator room.

Offices for student organizations are also included in the first six floors. The Student Council, THE TEXT, The Student Union Organization and the PICKOUT are among the clubs and societies having offices in the Union.

The operational policies of the Union will be determined by the Student Union Organization, a student group, in conjunction with the Student Union Director and the L.T.I. Building Authority.

The upper twelve floors contain dormitory facilities for approximately 500 students and provide the most luxurious dormitory facilities on campus. The furnishings were chosen by students acting with the Dean of Student Affairs and represent the latest in fashion, function and comfort. Kitchen facilities are on every other floor and on four floors, specially designed T.V. lounges augment the spacious floor lounges.

The Student Union Building in terms of student life is L.T.I.'s greatest asset.

STUDENT HOUSING AND SERVICES

Residence Halls

The LTI campus is oriented to a program that recognizes the educational advantages of both classroom instruction and extracurricular activities. Residence hall living provides valuable exposure in this regard. Consistent with this philosophy, it is the policy of the Board of Trustees that all non-commuting students are required to live in the residence halls on campus insofar as our facilities permit unless excused by the Dean of Student Affairs. Excuses are reviewed periodically and may be cancelled should conditions warrant.

For purposes of implementing the above policy a commuting student is defined as one who commutes to and from the Institute on a daily basis while residing at home with parents or guardian.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Student Affairs. When permission is granted to live off campus, the students must record, in the Dean of Student Affairs' Office, their off-campus local address. Further, the students are obliged to notify the Dean of Student Affairs' Office of any subsequent change during the academic year.

A list of off-campus rooms and apartments is provided, upon request, by the Housing Office to students who have been accorded permission to occupy other quarters.

Rooms are contracted for the full academic year EXCLUSIVE OF PERIODS WHEN THE INSTITUTE IS IN RECESS. Students are not permitted to remain in the residence halls during periods when the Institute is not in session. The Institute is not responsible for providing housing accommodations during vacation periods. Those students who cannot travel home during these periods must make their own off-campus arrangements for housing. No resident student is permitted, at any time, to maintain housing other than his residence hall assignment.

Upperclassmen are given choice of rooms and roommates in the spring of each year. Incoming freshmen are assigned dormitory space by the Housing Office in the order in which application data sheets are received.

Residence hall facilities are available for the housing of female students. Because of the increasing number of women in attendance at the Institute, spaces in these halls must be assigned on a priority basis. Applications will be processed in order of receipt.

Room assignments in residence halls are made for the academic year except as above noted. A change of rooms is not permitted except in rare instances and may be accomplished only after formal application is made to the Resident Advisor and approved by the Housing Office.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each occupant of a room is responsible for damage to furniture, equipment and interior surfaces. In the event of damage to public areas (corridors, lobbies, shower rooms, etc.) the cost will be apportioned among all residents of the building concerned.

It is the responsibility of each resident student to make arrangement for sheets, pillow cases, towels, blankets, pillows, etc., by subscribing to the linen service provided to all resident students at a nominal fee; or to supply these items himself, in which case he is responsible for the laundering thereof. Machines are provided in the various buildings for this purpose.

The room rental charge is $600.00 per year payable by the semester. Payment for the first semester is due on or before August 15 or, in the case of late acceptance, within fourteen days of receipt of bill. Second semester fees are due and payable as noted on the invoice.

Resident Food Service

Each resident student must purchase a meal ticket. Meal tickets are issued to the individual purchaser and are not transferable. Lost meal tickets are replaced at the Business Office at a charge of $5.00.

The present dining hall fee is approximately $400.00 per year, payable by the semester, in conjunction with the room charge. This fee is currently under study and is subject to revision.

THE BOARD OF TRUSTEES RESERVES THE RIGHT TO CHANGE ANY OR ALL FEES WITHOUT PRIOR NOTICE.

Refunds

In the event of withdrawal from the Institute, resident student fees for room and meals are refundable in accordance with the tuition refund schedule. (catalogue page 31)

Institute Dining Facilities

The Institute provides two complete dining facilities: The Student Union Dining Hall and Smith Dining Hall.

Smith Dining Hall has, within the past year, had a complete kitchen renovation and a replacement of all equipment in the interest of modern, efficient service. This dining hall is used by all residents of Eames Hall, Smith Hall and the Annexes. The Student Union Dining Hall is for the use of residents of Bourgeois, Leitch and the Towers Complex.

The facilities of both dining halls are available to commuters, faculty and staff on a cash basis. Hours of operation are posted in each hall.

Cafeteria and Snack Bar Services

The Rathskellar in the Student Union and the Smith Hall Cafeteria provide lunch, sandwiches and snacks and are in operation on a daily basis. Hours are posted.

Catering Service

The resident food service is available for catering service to student clubs, organizations or planned activities.

Residence Hall Counseling

The counseling staff of each residence hall is supervised by the Resident Advisor and coordinated by the Dean of Student Affairs. They are responsible for the counseling, education, athletic, and social programs in the residence halls.

Under the guidance of the Resident Advisor, the floor counselors lend assistance and support to the development of interest in a strong responsible and active student organization. This necessitates imagination, skill, and initiative action on the counselors' part.

The entire residence hall staff assists the students, individually and collectively, in their orientation to resident hall life and communicates the philosophy that their total living and academic environment will be no better than the sincere contribution each of them makes to it.

The counseling staff is of great assistance to freshman resident students in familiarizing them with the various clubs, organizations, educational and cultural programs available at the Institute. With proper direction, extra-curricular pursuits can be a meaningful part of the student's total education.

Applications for residence hall counseling positions are accepted early second semester for the following year. Each applicant will be interviewed by a Resident Advisor and the Assistant Dean of Students. All applicants will be notified of the results of their application prior to the end of second semester.

Residence Hall Regulations and Advice

These are general guidelines offered for the good of all resident students. Areas not covered in these guidelines must be cleared through the Resident Advisor and the Dean of Student Affairs' Office.

Eligibility. To be eligible for residence a student must be enrolled at Lowell Technological Institute as a full-time undergraudate degree candidate. Full-time is defined as enrollment for 12 or more credit hours per semester. Graduate students who meet full-time standards are eligible for residence during the period of their attendance, contingent upon availability of space. Individual housing eligibility is not transferable.

Vacation periods. The residence hall will open to residents during the college year as specified in the academic calendar. Residence halls are closed during the Thanksgiving, Christmas, and Spring vacations, and/or the period between the end of first semester exams and the start of second semester.

Entry to student rooms. Entry to student rooms will be governed by the policy developed by the Inter-dorm Council and the Dean of Student Affairs Office. This policy will be distributed to all resident students by the residence hall's government.

Personal property. Resident students are responsible for their personal belongings. The Institute does not assume responsibility for stolen personal articles. The Housing Office recommends that each student acquire some type of insurance coverage for their protection.

Cleanliness. Students are responsible for the cleanliness of their rooms and must maintain reasonable sanitation and safety standards. Waste materials should be removed regularly. Students are responsible for cleaning their rooms at the time they move out of the residence hall. If the Institute must clean the room a charge of $5.00 will be made.

Painting. Residents may paint the walls of their rooms under conditions as posted in the residence halls.

Pets. For health and safety reasons no animals or pets of any kind are permitted within the residence halls.

Room furnishings. The Institute provides the following in each room: spring, mattress, desk, study chair, closet or wardrobe and window shades or venetian blinds. The Institute does not supply linen, bedspreads, pillows, waste baskets or lamps. A commercial linen service is available if rental of linen is desired.

Water beds are explicitly prohibited from residence halls. Cooking appliances, hot plates and refrigerators are not permitted. Electrical appliances such as radios, clocks, record players, tape recorders, electric shavers, coffee pots, irons are permitted. Upperclassmen may have television sets.

Room telephones. Students residing in the new Towers Complex may have individual phones installed in their rooms. Other residence halls are not equipped for this service. Informa-

tion about phone service is available from the Lowell Business Office of New England Telephone Company. All phone service arrangements are made between the student and the Telephone Company.

Bicycles and motorcycles. Motorcycles may not be parked inside the residence halls. Appropriate arrangements for the parking of motorcycles and bicycles can be made at the Institute Security Office and/or through the Resident Advisor.

Lost keys. Lost keys will be replaced at a cost of $2.00 by contacting your Resident Advisor.

Visitation policy. Residents are permitted to entertain guests in accordance with the visitation policies in effect in each hall as established by the Board of Trustees.

All guests who intend to stay overnight must register with the Resident Advisor and are subject to the rules and regulations of Lowell Technological Institute. (An overnight guest is defined as a person remaining after 1:30 A.M.) The host student is responsible for the guest's actions. If another student's bed and room are to be used, permission for use must be obtained in writing.

Health Services - refer to page 56. **Student Services**

Parking. All residents are bound by the Institute parking regulations. These regulations are available at the Institute Security Office and are posted in the residence halls.

FRESHMAN RESIDENT STUDENTS ARE NOT PERMITTED AUTOMOBILES.

Financial obligations. Before assuming residency, each student must fulfill all financial obligations to the Institute for the semester.

Alcohol. The alcoholic beverage policy of the Institute, as posted in residence hall lobbies, must be adhered to.

Drugs. All ILLEGAL drugs are prohibited in the residence halls.

Weapons. Civil statutes prohibit the possession of firearms, fireworks, or any other device of an explosive nature in residence halls. In addition, Institute regulations prohibit weapons fired via a CO_2 cartridge, pump action, or pneumatic action in the residence halls. Bows, arrows, crossbows, slingshots or any other instrument which could be considered a weapon are also prohibited.

Solicitation. Commercial activities, solicitation or advertisement are not permitted in the buildings or on the grounds of the Institute Residence Halls except when permission has been specifically granted by the Dean of Student Affairs Office.

Use and Treatment of premises. No objects may be dropped or thrown from windows. Residents may not enter

upon, cross or use rooftops in any manner without specific written authorization from the Housing Office. Tampering with locks and altering or duplicating Institute keys are prohibited.

STUDENTS MAY BE ASKED TO VACATE THE DORMITORY WHEN IT IS IN THE BEST INTEREST OF THE INSTITUTE.

The residence halls are not athletic complexes designed for athletic competition. Therefore, athletic endeavors in any area of the residence halls are prohibited.

Counseling

The counseling program, under the supervision of the Dean of Student Affairs Office, starts with the admission procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Director of Student Counseling for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Director of Student Counseling.

Due to the increasing numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the counseling program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions.

Counseling in the upper classes is generally conducted in scholastic matters by the Head of the Department concerned and in personal problems by the Dean of Student Affairs Office.

A Foreign Student Adviser is available for counseling regarding problems relating to students from other countries.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening School are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE $10

The application fee is NOT credited to the student's tuition.

PREPAYMENT

The Institute requires the prepayment of 50% of the first semester's tuition within 12 days of the date upon which the applicant is accepted. For Massachusetts residents this amounts to \$50.00. The prepayment is refundable if the student notifies the Office of Dean of Admissions in writing on or before June 1, that he does not intend to enroll.

TUITION

Massachusetts domociliaries who qualify as "Resident Students" .... **(per academic year) $200**

Participants in the New England Board of Higher Education Regional Student Program .... **(per academic year) $200**

All others .... **(per academic year) $600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

Massachusetts domiciliaries who qualify as "Resident Students" .... **\$10.00 per cr. hr.**

All others .... **\$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. A "Resident Student" is defined as one who has maintained a domicile in Massachusetts for a period of not less

than one continuous calendar year next preceding the beginning date of the academic period for which he registers.

2. Every student claiming status as a "Resident Student" must file with the Dean of Admissions a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.

3. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student, who has been emancipated must also present documentary evidence of emancipation.

4. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.

5. Ordinarily, the residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.

6. A citizen of any country other than the United States who is in this country on a permanent immigration visa can be classified as a Massachusetts "Resident Student" if he has been domiciled in the state for a period of not less than one calendar year next preceding the beginning date of the academic period for which he registers under circumstances indicating his intention to reside permanently in Massachusetts.

7. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. A person asserting a particular place as his domicile shall furnish evidence to support such assertion. The burden of proof in all cases is upon the person making the assertion.

Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.

8. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.

9. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

OTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipent used for ROTC instruction and is required of all students erolled in that program. The entire amount, minus charges, is rfunded upon completion of ROTC requirements. If, at any tne, the charges against a student exceed the amount on depsit, he must pay the charges and make an additional deposit of $5.

STUDENT ACTIVITY AND INSURANCE FUND $60

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALL FEE................ per academic year $600.00

Payable by the semester

DINING HALL FEE.....per academic year approximately $400.00

Payable by the semester

STUDENT UNION FEE .... per academic year $70.00

The Late Registration Fee applies in the following situations, and is payable only once during each semester:

1. Preregistration
2. Registration
3. Payment on due date indicated on bill

AUDITING FEE .... $5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Student Affairs

Students not regularly enrolled or not paying the full tuition may in rare cases audit subjects at L.T.I. for no credit or grade providing they have permission of the Dean of Admissions and the Dean of the college in which the subject is offered.

To be considered, a student must file a regular application form with the Dean of Admissions and state specifically the subject by course number which the student wishes to audit.

Application deadlines for Audit are as follows:

Spring — January 2
Fall — June 1

COMMENCEMENT FEE $25

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES $5

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But Less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER ACADEMIC YEAR

Tuition

Massachusetts domiciliaries who qualify as "Resident Students" **$200**

Participants in the New England Board of Higher Education Regional Student Program **$200**

All others... **$600**

Residence halls, per year **$600**

Meal fee, per year .... **approximately $400**

Dormitory Damage Deposit .... **$ 25**

Student Union Fee .... **$ 70**

Student Activity and insurance fee .... **$ 60**

ROTC deposit .... **$ 25**

Books, supplies, and related miscellaneous expenses (approximate) **$100**

HE BOARD OF TRUSTEES RESERVES THE RIGHT TO CHANGE NY OR ALL FEES WITHOUT PRIOR NOTICE.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

Fundamental to the principle of independent learning and professional growth are the requirements of honesty and integrity in the performance of academic assignments, both in the classroom and outside, and in the conduct of personal life. Accordingly, the Institute expects of its students the highest standards of intellectual integrity and thus the attempt of any student to present as his own any work which he has not performed or to pass any examinations by improper means is regarded as a most serious offense and renders the offender liable to immediate expulsion. The aiding and abetting of a student in any dishonesty is also considered a grave breach of conduct.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Full-Time Student

A full-time student is normally considered to be carrying the credit-hour load called for by the curriculum in which he is enrolled. However, since students are sometimes out of phase with the specified curriculum, for purposes of classification an undergraduate student may be classified as full-time if his approved program consists of at least 12 credit hours.

Attendance

1. All students must attend all classes except under the following conditions:

   a. At the beginning of each semester, the instructor will present his attendance system for his particular class or classes in such a way that there will be no misunderstanding between the student and the instructor.

   b. Each instructor will allow each student a minimum of unexcused absences from lectures. The minimum number of lecture absences allowed per semester will equal the number of lecture hours of class per week. Any allowable unexcused absences above this minimum are left strictly to the discretion of the instructor. However, each student will be held responsible for any unannounced quizzes or

other material that may be given during his or her unexcused absence from class.

c. Laboratory attendance will be left entirely to the discretion of the instructor. If the instructor so desires, he may stipulate no laboratory absences.

d. Senior and junior students on the Dean's List the previous semester will be allowed unlimited absences. During the second semester of the sophomore year, sophomore students who were on the Dean's List for the first semester of the sophomore year will be allowed twice the minimum number of unexcused absences. There will be no extra privileges for freshmen or first semester sophomore Dean's List students.

2. If a student violates the above attendance system, the class instructor will report the student's name to the Office of the Dean of Student Affairs immediately. Upon notification from the Office of the Dean of Student Affairs or from the class instructor, the student must report to the Dean for appropriate action. Failure to report to the Dean's Office immediately could result in suspension from all classes.

The Dean will notify the student's instructor or instructors of his action within twenty-four (24) hours from the time the instructor reported the student to the Dean. The student will be readmitted to class only with written permission from the Dean.

If the Dean's action results in probation or suspension from classes, it will be entered on the student's personal record.

3. Lateness may be considered an absence at the option of the instructor. Except for Final examinations or other work missed due to an absence may be made up or failed at the option of the instructor. HIS RULING IS FINAL ON THE MATTER, EXCEPT IN THE FOLLOWING CASES:

a. Where absence is due to a death in the immediate family.
b. Participation in an official school function.
c. Participation in a selective service obligation, or
d. An extended illness (three days or more)

After each of the above has been verified by the Dean of Student Affairs Office, the instructor must grant the student make-up privileges.

Therefore the Dean's Office cannot issue excuses for one day illness, an appearance in court, late trains, oversleeping, etc. The cuts are given to cover these contingencies and the student must make his peace with his instructor.

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester.

Any changes in courses or curricula must be accompanied by an academic petition.

Incomplete Grades

The grade of I for undergraduate students shall only be reported:

When a portion of the assigned or required class work or the final examination has not been completed because of necessary absence of the student due to serious illness or extreme personal or other circumstance beyond the student's control. If the student's record is such that he would fail the course regardless of the result of the missing work, he is to be given an F.

In order to qualify for an I, the student must obtain an Academic petition form from the instructor or from the Office of The Dean of Student Affairs. Such a form would not be issued if the quality of the work to date did not warrant it. This form must be approved by the Dean of Student Affairs, with copies returned to the instructor and filed with the Registar.

A student can obtain credit for an I only by finishing the work of the course within two weeks from the end of the semester. The grade of I is converted to F if the course requirements have not been satisfied by this time. Exceptions to the two-week deadline may be requested on the Academic Petition and approved by the Dean of Student Affairs Office in cases of protracted illness or critical personal problems or for academic reasons at the request of the instructor. The initiative for removal of the I rests with the student, but faculty members giving an I must be responsible for making suitable arrangements for its removal.

An I on a final grade report is calculated as an F in arriving at a temporary rating. When the I is later converted to a grade, the permanent record is changed and the student notified.

A corrected grade report will be issued.

Academic Symbols "W" and "X"

"W" and "X" are used to indicate that a student did not complete subjects and that no academic grades were given. "W" indicates that a student withdrew from the Institute for approved reasons and it would appear for all subjects he was taking at the time of withdrawal. "X" indicates that a student dropped a subject for approved non-academic reasons after the time specified in the academic calendar as the last date to add or drop subjects without approval. No "X" or "W" symbol will be issued during the last three weeks of classes of any given semester.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

PROBATION AND DISMISSAL — ACADEMIC

Probation

A student is automatically placed on probation under the following conditions:

A. When the student's semester rating is less than 1.35

B. When the cumulative rating of a student not on probation is less than the appropriate value

Freshman Year-end	1.40
Sophomore Mid-year	1.45
Sophomore Year-end	1.50
Junior Mid-year	1.55
Junior Year-end	1.60
Senior Mid-year	1.65

The probationary period covers the entire regular semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the institute in any public function or extracurricular activity and may not hold or run for any class or other offices during the term of probation and is allowed no unexcused absences from classes.

Dismissal

A student is automatically dropped from the Institute for at least one semester under the following conditions:

A. When the student's semester rating is below 0.70 except first Semester freshman year.

B. When the student's semester rating is less than 1.35 for two consecutive semesters

C. When the student, while on academic probation, fails to achieve the cumulative rating required, in the foregoing statement on Probation.

Upon request of a student who has been notified of impending academic dismissal from the Institute by the above conditions, the Dean of Student Affairs Office, in the case of a freshman, and the appropriate Department Head, in the case of an upperclassman, will grant the student a hearing to review that student's case to ascertain if extenuating circumstances exist which would justify further consideration.

A student dropped from the Institute should see Readmission Policies. (p. 38)

PROBATION AND DISMISSAL — DISCIPLINARY

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

Disciplinary Action

The privileges of the Institute may be withdrawn from any student at any time if such action is deemed advisable. It should be understood that the Institute, acting through the Board of Trustees or any administrative officer designated by them directly reserves the right, not only to suspend or dismiss students, but also to name conditions under which they may remain at the Institute. Notation of disciplinary action is made a part of the permanent record of the student.

DISCIPLINARY PROBATION AND DISMISSAL

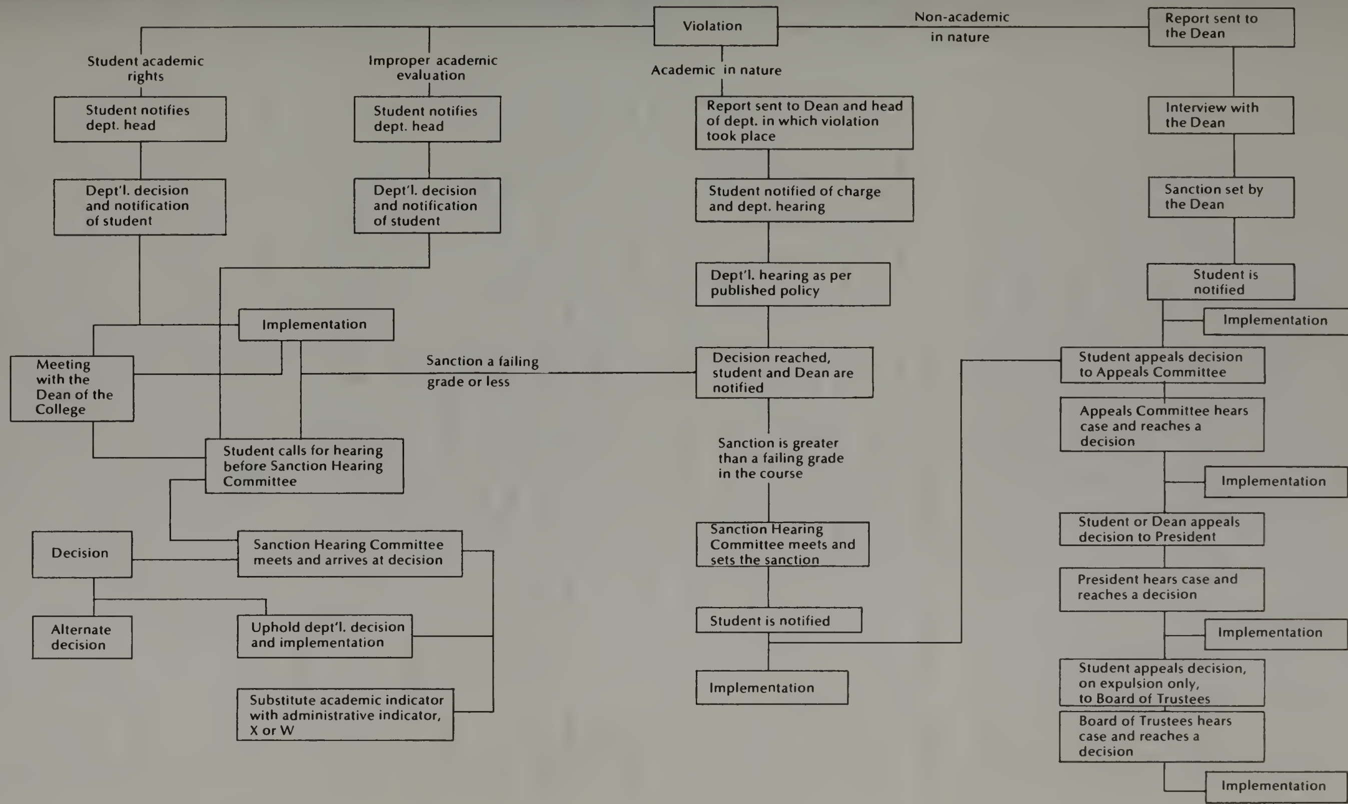
A student is placed on disciplinary probation by the Dean of Student Affairs when in his opinion a student has violated a basic rule of conduct or an established rule of the Institute. The probationary period covers the entire semester in which the violation took place. The length of time of the censure can be a longer period of time.

A student who violates the basic tenet of disciplinary probation may be dismissed from the institute.

If the original violation is of a serious nature, the Dean of Student Affairs may dismiss the student without benefit of a probationary period.

Any student on disciplinary probation may not represent the Institute in any public function or any extra-curricular activity, and may not hold or run for any class office or other office during his term of probation. Nor is he allowed to cut any classes or laboratory sessions.

DISCIPLINARY PROCEDURE FLOW CHART



A student who is on academic probation may not be excused from any class to participate in any extracurricular function or activity. Further, *if the probationary period occurs during his freshman year, he may not represent the Institute at any such function or activity at any time during that period. He may become a member of any organization at the Institute, such as a club or fraternity, but he may neither run for, not hold, any office in such an organization or in his class while on probation.* If the probationary period occurs after his freshman year, he may represent the Institute at extracurricular functions and activities at times other than class times and may run for, and hold offices in organizations at the Institute and in his class providing written permission from the Dean of Students has been obtained.

WITHDRAWAL FROM THE INSTITUTE

Students wishing to withdraw from the Institute at any time must secure and have completed a Withdrawal Clearance Form from the Office of the Dean of Student Affairs. Students withdrawing from the Institute **prior** to the end of the semester shall receive all "F's", except for reasons of medical withdrawal, involuntary call to active duty, and/or other extenuating circumstances approved by the Dean of Students.

LEAVE OF ABSENCE: FOR STUDENTS IN GOOD STANDING

Students in good standing who find it necessary to withdraw at the end of any semester because of military service, health, financial reasons, or personal problems, may be granted a leave of absence from the Institute by the Dean of Student Affairs Office. The student must complete a Withdrawal Clearance Form obtained from the Dean of Students office. Readmission will be automatic for a period of up to two years and would require only the filing of a Readmission Application.

READMISSION POLICIES

Requests for readmission will be handled by the Dean of Student Affairs Office. All correspondence should be sent to this office. The procedure to follow and all information needed is listed below.

1. Students desiring consideration for readmission must submit pages 1 and 2 of our application.
2. Student Data Sheet must be completed in its entirety.
3. A Check in the amount of $10.00 made out to Lowell Technological Institute must be included.
4. A letter giving original date of entrance to this college, date and **reason** for withdrawal and a brief resume of what you have done since you left L.T.I. must accompany the application. (N.B. If withdrawal was for medical reasons, you must include a doctor's certificate certifying ability to attend school again).
5. Students desiring transfer credit should supply an official transcript sent to us by the colleges attended. Only those cours-

es graded in "C" range or better will be considered. Those students who withdrew because of scholastic difficulty must have had prior approval on the required credit form obtained at the Registrar's office in order to have their courses considered for credit.

6. Completed applications for September readmission must be received no later than May 15.

Completed applications for February readmission must be received no later than January 1.

7. When the Dean of Student Affairs deems it necessary a student will be asked to make himself available for an interview.

8. Only when all of these items have been received in the Dean of Student Affairs office will the application be considered for readmission.

Final decision will be made by the Dean of Student Affairs Office and/or the Department Head for upperclassmen as to whether or not readmission would serve the best interests of the student and the Institute. Approval of readmission is not automatic and all decisions will be final.

9. A letter will be sent notifying you of the decision from the Dean of Student Affairs Office. No notification will be given by telephone or in person.

RULES OF CONDUCT

The Board of Trustees recognizes the dual obligation of the Institute to insure the orderly pursuit of its proper functions at all times while preserving the rights of individuals and groups to freedoms guaranteed by our national and state constitutions and normally prevailing in the academic community. The Board of Trustees recognizes and defends the right to open discussion, the right to hold and articulate one's own beliefs and convictions, the right of peaceful assembly, the right to petition, the right to distribute handbills and circulars, the right to a fair hearing, and such other rights as are inseparable facets of the concept of academic freedom and are indispensable for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. The basic distinction to be made is that between those activities which are consistent with our obligation as an academic institution dedicated to free inquiry and free expression and to safeguarding the freedom to teach and the freedom to learn and those activities which are inconsistent with this obligation. It follows that there is a responsibility for the Institute to draw clear distinctions between conduct on the part of members of the Institute community and visitors to the Institute which is acceptable and that which is not. The rules set forth below are effective in accordance with the existing laws of the Commonwealth and the nation.

The following activities are among those which are considered unacceptable because of their adverse effect on the preservation of freedom or on the orderly pursuit of Institutional work:

1. Obstruction or disruption of teaching, research, administration, or other Institute activities, including the Institute's public service functions or of other authorized activities, on Institute owned or controlled property;
2. Obstruction of the free flow of traffic, both pedestrian and vehicular, on Institute owned or controlled property;
3. Physical abuse or detention of any person on Institute owned or controlled property or at any Institute sponsored or supervised functions, or conduct which endangers the health or safety of any person;
4. Theft or damage to property of the Institute or of property of a member of the Institute community or the property of a visitor to the Institute;
5. Unauthorized entry to or use of Institute facilities, including both buildings and grounds;
6. Violation of Institute established policies or regulations, including regulations in the Catalogue, and other publications pertaining to student organizations, student, faculty, administrative staff, non-academic employees and visitors conduct, the use of Institute facilities, or procedures concerning the time, place and manner of public expression;
7. Violation of rules governing residence in Institute owned or controlled property;
8. Use, possession, or distribution of narcotic or illegal drugs on Institute owned or controlled property, except as expressly permitted by law;
9. Failure to comply with directions of Institute police and any other law enforcement officers acting in performance of their duties and to identify one's self to these officers when requested to do so;
10. Illegal or unauthorized possession or use of firearms, explosives, dangerous chemicals or other weapons on Institute owned or controlled property.
11. Failure to comply with the directions of Institute officials acting in the performance of their duties;
12. Disorderly conduct, breach of the peace, and aiding, abetting or procuring another to breach the peace on Institute owned, or controlled property or at Institute sponsored or supervised functions.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in major subject.

2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.

3. Fulfill the residence requirement of one academic year.

4. Financial clearance: Degrees, diplomas, transcripts of record and letters of honorable dismissal will be withheld from all students until all accounts with the Institute are settled. The term "account" includes any indebtedness to the Institute.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors — graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors — graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors — graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Direct Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates for Financial Aid through either the College Scholarship Service Princeton, New Jersey or American College Testing Service, Iowa City, Iowa.

Students may obtain applications and information regarding these programs at the Financial Aid Office in the Alumni Library Building.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the

scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Financial Aid Officer before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for test, candidates must make direct application to the College Entrance Examination Board, P.O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Alumni Association Scholarships

The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from individual Alumni, corporations, scholarship funds and foundations.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and children or grandchildren of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is

renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

AFROTC College Scholarship Program

High school students desiring information on the 4-year AFROTC College Scholarship Program should see their school guidance counsellors or write directly to AFROTC (OTTA), Maxwell AFB, Alabama 36112 for further information. Normal deadline application is 15 November each year.

Scholarships are provided on a competitive basis to a limited number of male and female cadets entering Aerospace Studies 200-300 in the Air Force ROTC four year program. The scholarship covers full tuition costs, books, laboratory expenses and incidental fees. A scholarship earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable standards. Cadets also receive $100 per month subsistence allowance.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, and Littleton, Mass.; West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

Outside Scholarship Assistance:

The Afro-American Society at L.T.I. has compiled a list of Private, Public, and Federal Scholarships, Funds, Fellowships, and Loan Programs that are available to disadvantaged persons.

The Financial Aid Office has copies of this list which will be sent upon request. Correspondence should be addressed to the Director of Financial Aid, Lowell Technological Institute, Lowell, Massachusetts 01854.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Corporation Scholarship

The Allied Chemical Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

Boston Paper Trade Association Awards

One award, of $300, is open to upperclassmen enrolled in the Paper Engineering Department. Awards are based on character, proven interest in the Paper Industry and academic performance.

Roland E. Derby, Sr. Memorial Scholarship

This Scholarship established in memory of Roland E. Derby, Sr. provides a $500 scholarship to a sophomore student who is a candidate for a degree in Chemistry, or Chemical Engineering in alternating years. Selection by the Scholarship Committee shall be based on scholastic achievements, but due consideration shall also be given to financial need. The scholarship shall be renewable for the Junior and Senior year provided the recipient maintains a satisfactory academic record.

Foster Grant Scholarships

The Foster Grant Company, Inc., of Leominster, Mass., makes available on a one-year basis two scholarships to deserving students in Plastics Technology who are residents of Massachusetts. Preference is given to sophomores living in the Leominster area; however, if there are no applicants from that area, other candidates may be chosen. Scholarship, personality, and overall student contribution to extracurricular activities are the general criteria used in selecting the recipients.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

Paper Engineering Department Scholarships

Ten or more scholarships with annual stipends of $500 are available to upperclassmen and selected graduate students in Paper Engineering who fulfill the scholarship requirements of a minimum of 2.0 cumulative rating. These scholarships are normally maintained from year to year provided the student maintains his academic rating.

Contributors to the Scholarship Fund include the following:

Albany International
Byron Weston-Crane Company
Cabot Corporation
Chas. T. Main Co.
Cheney Bigelow Wire Works, Inc.
Deerfield Glassine Co.
Dennison Foundation
The Dexter Corporation
Draper Brothers Company
E. F. Houghton and Co.
Erving Paper Mills
Fraser Paper, Ltd.
Gulf States Paper Company
Ludlow Corporation
Nashua Corporation
Weyerhaeuser Company

Rohm and Hass Corporation Scholarship

The Rohm and Hass Corporation has made available on a one-year basis a scholarship for an upperclassman majoring in Plastics.

S.M.E. Awards

Merrimack Valley Chapter 113, Society of Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The S.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

William C. Smith Trust Fund Scholarship

This fund has been established to provide scholarship assistance to students majoring in Chemistry.

Society of Plastics Engineers Scholarships

Two scholarships are granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to upperclassmen majoring in Plastics Technology.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial

need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry in the amounts of $225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school, interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

AVAILABLE TO UNDERGRADUATE AND GRADUATE STUDENTS.

National Direct Student Loan

The Higher Education Act of 1965 offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3% beginning with the first payment. Repayments may be made over a 10-year period.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

SME Award. The Merrimack Valley Chapter, Society of Manufacturing Engineers awards $100 to a member of the Student Chapter of the SME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular

activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

The Wall Street Journal Student Achievement Award. This award recognizes the senior in Business Administration or Industrial Management who has achieved the best combination of academic and extracurricular excellence. The award consists of an engraved paperweight, a year's subscription to the Wall Street Journal, and a plate on the permanent plaque established for the award winners.

OTHER ASSISTANCE FOR MASSACHUSETTS Residents Only

Board of Educational Assistance Scholarships

General Scholarships provide for tuition payments and are available primarily to freshmen and are based solely on financial need. Honor Scholarships provide for tuition and are based solely on academic ability (SAT scores). Scholarships are also available to the children of deceased uniformed members of a paid fire department or permanent members of a police department, the force of the MDC, or the Capital Police. Such death must have been the result of injuries received in the line of duty. For full information contact:

Board of Higher Education
Scholarship Office
182 Tremont Street
Boston, Mass. 02111

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1500 a year for undergraduate school, or $2000 a year for graduate school. There is no interest charge on such loans while

the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 7% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Massachusetts 02116
Telephone 426-9434

Veterans

G. I. Bill

Veterans attending LTI may apply for financial assistance under the GI Bill. Application should be made to your local VA Office for details. Proof of your student status should be obtained by presenting your acceptance from the Admissions Office and, upon registration, the Registrar's Office should be requested to notify the VA as to your student status.

G.I. Bill payments will be pre-paid in 1973 and future years. Checks may be picked up at the Bursar's Office after Registration.

Certificate of Elgibility

Veterans whose service is credited to Massachusetts are entitled to free tuition for four years at Massachusetts colleges. In order to obtain the Certificate you must present your discharge paper (DD 214) to the Adjutant-General's Office in the State House in Boston. Upon receiving verification, you should bring it to the Massachusetts Department of Education at 182 Tremont Street, Boston and request the Certificate. A request should then be filed with the Office of the Registrar during registration to inform the Department of Education as to your status and also with the Bursar's Office to the effect that you will present the Certificate to them when you receive it.

THE THREE CATEGORIES BELOW CLASSIFY OUR STUDENTS AS VETERANS IN TERMS OF THE PHYSICAL EDUCATION REQUIREMENT AT THE INSTITUTE:

1. National guard — six-year period — discharged and military obligation completed.
2. National guard — six-months active duty completed and serving five and one-half years of reserve training.
3. Student who fulfills military obligation on active duty in the armed services.

PLACEMENT

The office of Career Counseling and Placement assists students and alumni seeking employment. Each year many companies and other prospective employers visit the Institute to interview students. The office of Career Counseling and Placement assists students in preparing for the interviews, helps them make out resumes of background and experience, and counsels them on employment opportunities. The office also maintains an extensive library of literature about specific companies, interviewing techniques and career guidance, all of which are available to students and alumni.

General Rules

A. Selection of Curriculum

Admission to the Institute does not automatically guarantee admission to specific curricula. A student must qualify for certain curricula during the freshman year by offering a minimum quality of grades in certain subjects. Freshmen should review these requirements in detail by consulting the Office of the Dean of Student Affairs early in the school year.

B. Change of Curriculum

1. A change in a course of study may be accomplished only upon approval of a petition to the Dean of Student Affairs and the several Division Heads concerned.

C. Schedule Changes and Withdrawal

1. Every student must attend the first meeting of all classes on his schedule. Entrance to class after the first meeting may be accomplished only with permission from the Office of the Dean of Student Affairs. No student may enter a new class later than the date designated by the Official Institute Calendar.

2. A student may drop a given subject provided permission has first been received from the Dean of Student Affairs Office, the proper Dean of the College and the Instructor involved.

3. A subject dropped after the date specified in the academic calendar shall automatically be counted as an unconditional or total failure on the part of the student, shall be so recorded on his scholastic record, and shall be used in computing his academic rating.

4. All dropped subjects, whether counted as a failure or not, which are part of the student's prescribed course of study, must be completed successfully prior to entrance into any other subject for which the subject dropped may be a prerequisite, and must also be completed successfully prior to graduation.

5. Students receiving a failure in any subject must, prior to graduation, successfully complete the subject or an equivalent substitute approved by the Dean of Student Affairs Office by the Division Heads concerned and by the Instructor in charge of the subject failed.

6. In constructing a student's hour plan for any given semester, first priority shall invariably be given to all subjects which have been dropped or failed in any preceding semester(s). Unless approved in writing by the Dean of Student Affairs Office upon written recommendation of the Head of the Division of the course curriculum involved, no course for the new semester shall be entered upon the new hour plan until all outstanding courses from preceding semesters have been scheduled.

7. In computing credit hours of work, certain subjects taken in the evening division may be considered part of the day program. Credit shall be given at the end of the term only for those hours which have been approved at the beginning of the term.

8. The normal credit hour load will vary slightly for each semester, as the total number of credit hours required in each prescribed curriculum will not always be the same.

9. A student who wishes to transfer from one section to another in any given subject must obtain in writing, the permission of the Dean of the College in which the subject is taught and the Director of Scheduling. He shall file a revised class schedule at the Office of the Dean of Student Affairs, and two revised class schedules and the written permission at the Office of the Registrar.

10. A student who voluntarily withdraws from the Institute must first make application to the Dean of Student Affairs Office and fill out the required "Withdrawal Clearance" form. Failure to comply with the required procedures of withdrawal shall result in forfeiture of the student's right to honorable discharge.

11. Special Action — Any deviation from normal academic program and procedures must be initiated by a Special Action Form (obtained at the Office of the Dean of Student Affairs). This sheet must then be completed and signed by all academic and administrative staff involved. The Dean of Student Affairs will not entertain any action sheet until it is complete in every detail. This form must be completed during the registration period.

Transfer Credit

All inquiries concerning transfer credit should be directed to the office of the Transfer Affairs at Lowell Technological Institute.

Examinations

1. Tests will be given in freshman subjects at the end of the first seven weeks of class. Students who have low grades at this time may be warned that continued scholastic difficulties may jeopardize their status as full-time students at the Institute. Instructors shall report these grades on all freshmen to the Dean of Student Affairs.

2. Final examinations are regularly given in all subjects at the end of each semester.

Group Meetings

A. As used in this section, group meetings are defined as business or educational meetings of regularly organized and officially recognized groups held in rooms or halls of buildings on the campus. Official meetings of fraternities, held at fraternity houses are excepted. Social gatherings and entertainments, or group meetings that are held "off campus" are governed by separate regulations.

B. Arrangements for group meetings shall be made as follows:

1. The president of the organization shall file the proper form at the Office of the Dean of Students not less than one week before the proposed date of the meeting.

2. Upon receipt of the preliminary approval of the meeting from the Dean of Student Affairs Office, the president of the organization shall present his copy of the approval to the Secretary of the Assistant to the President of the Institute to reserve the space selected for the meeting, and then return the form to the Dean of Student Affairs Office.

Note: Reservations must include all arrangements for extra janitor service and clearance with any Institute authorities concerned.

C. Arrangements for group meetings shall include arrangements for the care and the reception of guest speakers, special guests, and any other groups invited to be present.

GENERAL SAFETY RULES AND REGULATIONS AT LOWELL TECHNOLOGICAL INSTITUTE

1. Reporting and treatment of injuries

Day school — Any member of the student body, faculty or other personnel incurring an injury at the Institute, must report immediately to the school nurse at the dispensary for treatment. If the injury is serious enough to warrant further medical attention, the nurse shall make an appointment with, or if necessary, call in attendance, a doctor of the patient's choosing. It should be understood, however, that if it is necessary for the injured to be treated by a doctor, the injured person, if not a State employ-

ee, must assume the responsibility for payment of the doctor's fee. In addition to caring for the injury, the nurse shall also file a copy with the safety Committee. This will enable the Safety Committee to investigate the accident and make whatever recommendations possible to prevent a recurrence. This should apply to both day and evening school.

2. **Fire Regulations**

Alarm Signal — A continuous ringing of the school bells shall indicate that there is a fire in the Institute and everyone, except those with specially assigned duties, shall leave the buildings by the nearest available exit and immediately go to the sidewalk.

3. **Bomb Threats**

When a bomb threat is received at the Institute switchboard, the school alarm system will give off three short blasts, repeated once. As soon as the alarm is sounded any student, regardless of whether or not the instructor decides to hold class, may leave the building without penalty. The student however, will be responsible for obtaining notes and/or assignments either from the instructor or some other student.

It should be clearly understood that this is a voluntary decision and can only be made by the student himself.

4. **Laboratory Regulations**

Safety Glasses — It is absolutely necessary that all students and faculty members shall wear suitable eye protective glasses in the Laboratories. This is in compliance with State safety requirements.

5. **Evacuating the Buildings**

Dormitories

In case of fire each student shall turn on his room lights, close windows and doors and leave the building by the nearest exit.

Library

Basement floor leave by tunnel exit. The remainder leave by nearest exit. If the fire should prevent the use of any one of the exits the next nearest one should be used.

6. **Air Raid**

In the event of an air raid within the area of the Institute, the school's air raid siren shall be sounded and the School's Civilian Defense Program will immediately go into effect. All members of the C. D. program shall assume the responsibilities assigned. The remaining school personnel will go to the nearest air raid shelter and remain there until the "all clear" is sounded.

7. **Smoking**

Smoking is forbidden in all classrooms and laboratories including the auditorium in Cumnock Hall. The 'no smoking' rule

is required by both the Massachusetts Department of Public Safety and the State Insurance Agency and therefore shall be strictly enforced. Smoking will be permitted in area designated as "Smoking Areas" and shall be controlled and confined to those areas.

Smoking areas will be designated in all of the buildings and smoking will be allowed only in those areas during school hours. Smoking is permitted in the faculty and staff offices, dormitory rooms and in the Cafeteria provided that the necessary ash trays and receptacles are available and are used properly. Smoking is prohibited in the auditorium, Cumnock Hall, at all times. A suitable area will be designated in the building for smoking. This area will be utilized for smoking during the day hours and must be the area in which all smoking takes place.

STUDENT SERVICES

Mailroom

The Students' Mailroom, operated by Lowell Technological Associates Inc. for the convenience of the students, is located in the second floor of Southwick Hall. Each student will be assigned a mailbox during registration week. The U. S. Post Office makes one delivery each day. Incoming mail is sorted and placed in the Student's mailbox as soon as possible. Notices from the administration and instructors are also placed in the student's mailbox as soon as possible. Students are urged to check their boxes frequently.

The mailroom facilities are available to organizations to insert circulars in boxes from 1:00 p.m. to 4:00 p.m. every day. Organizations must distribute their circulars and notices, mailroom personnel are not to be requested to perform this work.

Mailroom Hours: Daily 8:30 a.m. to 12:00 noon
and 1:00 p.m. to 4:30 p.m.
except on Friday when the
mailroom closes at 4:00 p.m.

Book Store

The College Bookstore operated by Lowell Technological Associates Inc. for the Institute is centrally located on the second floor of Southwick Hall. All the required textbooks are carried. In addition, school supplies, drafting equipment, slide rules and general and technical reference books are offered in substantial volume and variety. A complete selection of paperback books, including general technical and classical readings are available to choose from. Catering to the student's non-academic needs, the store also features such items as campus wear, greeting cards, posters, records, tapes, toiletries, magazines, newspapers and novelties. College oriented merchandise includes pewter and ceramic mugs, jewelry, decals and banners. The store welcomes

fraternities, clubs and other organizations who may desire specialty or novelty items to come in and look over their complete line of such goods.

All students are entitled to a 5% discount on any and all purchases over $1.00. As part of their service to the students the bookstore has made provisions to purchase used textbooks from students who wish to sell their books at the prices quoted in the used book manual during designated times of the academic year. As an additional service, the store will special order any book not in their stock for the student.

Health Services

The Health Services Building is located at 30 Standish Street, behind the new addition to the Alumni Library. The Health Service is open from 8 a.m. to 11 p.m. Mon thru Thurs, 8 a.m. to 5 p.m. Friday and is staffed by Dr. J. Martin Zinaman, school physician, Mrs. Arlene D. Wuester, R.N., Mrs. Janet E. Conners, R.N. and Mrs. Gloria Richards, R.N. In cases of emergency, medical coverage is available on a 24 hour a day basis.

Accident insurance coverage during the academic year is obligatory and is included in the Student Activity Fee and Insurance Fund. Health insurance, which is optional, is available at a nominal fee at the time of registration. Insurance claim forms may be obtained at the Health Services office and must be completed as soon as possible after an accident or illness. Failure to comply within the designated period of time may result in the student forfeiting his insurance coverage.

ALUMNI MEMORIAL LIBRARY

The new Alumni Memorial Library complex opened in 1970. The new addition located between Smith and Eames dormitories is connected via ramps to the original Library building. This building, constructed and equipped by the L.T.I. Alumni Association in 1951 houses our rare books, technical reports and government document collections.

There is only one entrance to the new library complex although the tunnel system feeds into this new entrance. Two of the old three entrances to the library became emergency exits only, while the entrance on the highway side continues to serve the alumni and student areas of the building.

The new addition houses a lobby, circulation desk, reserve book room, reference room, card catalog and library office areas on the main floor. The third floor houses a vast periodical room, study room, periodical office and a microprint area. The fourth floor houses our collection in science and technology and study and discussion rooms. The top floor houses the humanities and social science collections along with study and discussion rooms.

The ground floor is devoted to the new Audio-Visual Area, and contains a small theatre (140 seats) and projection room, a large student listening room and six individual listening rooms served by a master control area, a microfilm room and the college's educational FM radio station (WLTI) which has a separate entrance.

The building is served by two public passenger elevators as well as stairs and ramps. The large rooms on the third, fourth and fifth floors contain stacks, reading and lounge areas.

Rules Governing Use of the Library

1. Silence is enforced in all stacks, reading and study areas of the library.
2. All bags, briefcases, etc. must be presented for inspection at the control desk before leaving the library.
3. As you leave the library, you must stop at the charging desk to sign out any books you are removing from our collection.

If you follow the few simple rules outlined above, and learn to use the library efficiently, you will be amazed at the perpetual aid and knowledge it can give you.

RELIGION AT TECH

On many college campuses there is serious interest, not just in classes or marks, but also in deeper issues such as the meaning of life itself. Here, at Tech., the various religious organizations and chaplains try to provide an atmosphere in which faith questions can be faced honestly and sincerely. While the value of an individual's religious background is stressed, there is ample opportunity in Lowell to learn about and cooperate with people of other religious persuasions. Whatever your faith or lack of faith may be, you will be most welcome. You are also invited to contact any of the chaplains regarding personal questions or problems.

THE NEWMAN COMMUNITY

The Newman Community of Lowell is composed primarily of Catholic students attending Lowell Technological Institute, State College at Lowell and Lowell General Hospital School of Nursing. In addition, students of other faiths or no faith are welcome to participate in any or all Newman activities.

The Newman Community is the visible presence of the Catholic Church on campus. As such, it is committed to worship in a meaningful way and to witness by serving others with love. Cooperation with other religious organizations, cooperation with student activity groups, and cooperation with social action in the area remain as the most important of Newman's goals.

The Newman Community is committed to:

1. The growth and development of the individual as a whole person - spiritually, intellectually, socially.
2. The building of community awareness among all segments of the colleges.
3. Responsible participation in school and civic affairs.

The Newman Center is located at 52 Colonial Ave. (VFW Parkway) at the corner of Mt. Hope St. You are welcome any day between 11:00 A.M. and 11:00 P.M. to study, to use the library or the recreational facilities.

The United Campus Ministry of Lowell

THE UNITED CAMPUS MINISTRY OF LOWELL is a federation of students, spiritual and faculty advisors of the various religious organizations of Lowell Technological Institute, Lowell State College and Lowell General Hospital School of Nursing, which sponsors ecumenical programs throughout the academic year. For information, contact Rev. Paul T. Walsh, the Chairman-chaplain at the NEWMAN CENTER.

Publications

Pickout

Lowell Tech's yearbook, the Pickout, is published each May and distributed to the entire student body.

The publication provides an account of the past year's activities but is especially significant for the graduating seniors as it also contains a retrospective glance at their four years at Tech.

The great amount of time and work required to produce the yearbook necessitates a large staff whose efforts begin early in September and end when all proofs and editing are completed in early Spring.

The Pickout offers an excellent opportunity to obtain valuable experience in diversified organizational work. The wide range of positions include photography, business and advertising management, layout, editorial and literary. More information is available from the Pickout office, located in the Alumni Memorial Library.

Newsletter

The Student Newsletter is published weekly to inform the Lowell Tech student body of social, professional and athletic activities. Items must be approved by the Dean of Student Affairs and should be left at the Public Relations Office in the basement of Cumnock Hall by noon on Monday of the week that the item is to appear in the Newsletter. The Newsletter is distributed to key areas throughout the campus on Tuesday morning. All items must be submitted on forms obtained at the Dean of Student Affair's Office.

"The Text" — The Student Newspaper

On February 1, 1919 a group of energetic and active students banded together to form the first Text staff. The purpose of the Text is to present all views concerning all matters directly or indirectly affecting the Lowell Tech community. Last year for the first time since its conception, the Text was published weekly.

The Text News Association is open to anyone who would like to join. The Text is the most active organization on campus, and being part of this organization puts the student ahead of everyone in awareness and involvement with everything that goes on at L.T.I.

To become a permanent member of The Text staff you must contribute in some way to the production of four editions of the newspaper. At that time you will be given full voting rights and the privilege to run for an editorial or managerial position on the Text.

There are always many positions and jobs available for anyone who wishes to join the Text. Each edition of the newspaper requires many photographers, reporters, writers, artists, business people, and typists.

The Text is published every Monday during the college year except on certain holidays and is produced by and for the students of Lowell Technological Institute. The Text News Association office is located in the basement of the Alumni Memorial Library, Lowell Technological Institute, Lowell, Massachusetts, 01854. Tel. 453-1872.

The pay is nothing, but the rewards are great.

SUMMER SCHOOL

All Summer Session programs are conducted on a self-supporting basis with no financial assistance from the Commonwealth of Massachusetts.

The programs are designed to serve the following areas of interest:

1. UNDERGRADUATE CREDIT PROGRAM

Two six-week sessions, paralleling the two 15-week academic year semesters, stress fundamental credit offerings in mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

These sessions provide an opportunity for deficiency clearance and for advanced standing.

2. PRECOLLEGE REFRESHER PROGRAM

This five-week, noncredit program caters to prospective L.T.I. freshmen who require additional background to fulfill minimum entrance requirements.

Students must first apply for fall admission; the Dean of Admissions designates the subject or subjects required for coverage of minor deficiencies in the high school background. Subject areas include: English, mathematics, chemistry, and physics for engineering applicants; English, mathematical analysis, and general science for business administration majors.

3. PROFESSIONAL ADVANCEMENT PROGRAM

Industry-sponsored noncredit courses, similar in scope to the **continuing education** courses conducted during the academic year, may be arranged during the Summer Session. Additionally, the SUMMER EVENING PROGRAM and courses conducted through special grants are offered under this heading.

Note: Summer evening offerings are conducted through the DIVISION OF EVENING STUDIES in a single, six-week session. Credits apply **only** to Evening Division Programs.

4. GRADUATE CREDIT PROGRAM

Selected graduate credit subjects are offered for students who have been admitted to advanced study by the L.T.I. GRADUATE SCHOOL. The Assistant Dean of the Graduate School must approve all offerings and registration is carried out through the Graduate School Office.

The L.T.I. Summer Session is a member in good standing of the National Association of Summer Sessions (NASS).

Individual brochures are available. Address inquiries to the Assistant Dean of the Graduate School.

THE MARTIN LUTHER KING, JR. EDUCATIONAL OPPORTUNITY PROGRAM

A program proposed by the Lowell Technological Institute Afro-American Society has been added to the Institute structure. This program is named in honor of the late Dr. Martin Luther King, Jr. the Nobel Laureate and champion of disadvantaged people of all races.

The King Educational Opportunity Program has been designed to provide an opportunity for higher education at LTI to individuals who have been hindered in their academic achievements due to adverse financial and environmental factors. The first program year will start in June of 1972. Thirty Massachusetts high school graduates will be enrolled in the program each year. They attend a summer session for program orientation, academic needs evaluation, counseling, and required remedial studies.

The normal course load, remedial studies, and tutoring assistance of students enrolled in the program will be adjusted to the needs of the individual. It is expected that the average student will complete the normal four year curriculum in five years. Students accepted into the program will receive full financial support for the five year period.

For further information, write to the Acting Director, Dr. Jesse Y. Harris.

THE GRADUATE SCHOOL

General Information

The Lowell Technological Institute Graduate School, which was founded in 1935, offers advanced studies, including professional training and research leading to graduate degrees in many fields of engineering and in certain areas of pure and applied science. In addition to the day classes intended primarily for full-time graduate students, the Graduate School offers some evening courses through the Division of Evening Studies mainly for the convenience of part-time students primarily interested in advanced professional training. The courses offered in the evening are equivalent in every respect to those offered to the day students for they are simply evening sections of courses offered during the day. There are currently 170 graduate students enrolled in degree programs for advanced professional training in these Evening Division courses out of a total Graduate School enrollment of 514 students. These part-time students are primarily from the large industrial companies nearby the Institute located principally in the Merrimack Valley. Professional graduate programs, which would include the graduate programs in Plastics, Paper, Textiles, Nuclear Engineering and Management Science are in wide demand by industry in New England and in Massachusetts in particular. These programs serve as excellent supplements to the standard curricula in the basic engineering and science areas which are listed below. In June of 1972 there were 41 Master of Science degrees and 3 Master of Management Science degrees granted through the Graduate School at LTI.

Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree or equivalent in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality. It is the policy of Lowell Technological Institute to accept all students without regard to race, color, or national origin.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed in duplicate and returned to the Dean of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by recommendations from at least three persons qualified to judge the ability of the applicant

to carry on graduate work and research. The recommendations should be sent directly from these persons to the Graduate School.

Two copies of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B− and if these subjects were not used in earning another degree at the same level. All applicants must submit one additional copy of a transcript which includes the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within one semester after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning two completed application forms and having transcripts and recommendations sent, the applicant must take the Graduate Record Aptitude Test and the appropriate Advanced Test and have the results sent to the Dean of the Graduate School. Information regarding the Graduate Record Examinations may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N.J. 08540 or Box 27896, Los Angeles, California 90027, whichever is nearest to the applicant.

Academic Expenses

Tuition (per semester)	
U.S. citizens who are residents of Massachusetts and	\$10 per credit hour up to \$100 maximum
Participants in the New England Board of Higher Education Regional Student Program	\$10 per credit hour up to \$100 maximum
All others including foreign students	\$30 per credit hour up to \$300 maximum
Graduate Student Activity Fee (per year)	\$32.00
Commencement Fee	\$25.00
Thesis Binding Fee (per copy)	\$5.00
Microfilm Fee (M.S.)	\$19.00
Microfilm Fee (Ph.D.)	\$29.00

DEGREES OFFERED

Master of Science Degrees

- Applied Biology
- Applied Mathematics
- Chemical Engineering
- Chemistry
- Computer Engineering
- Electrical Engineering
- Environmental Studies
- Mathematics
- Mechanical Engineering
- Nuclear Engineering
- Paper Engineering
- Physics
- Plastics
- Polymer Science
- Radiological Sciences
- Systems Engineering
- Textile Engineering

Doctor of Philosophy Degrees

- Chemistry
  - a. Inorganic
  - b. Organic
  - c. Physical
- Chemistry — Polymer Science Option
- Physics (Experimental and Theoretical)
  - a. Nuclear
  - b. Solid State
  - c. Particles & Fields
  - d. Underwater Acoustics

Professional and Other Degrees

Master of Management Science (M.M.S.); Master of Mathematics for Teachers (M.M.T.)

For further information concerning the graduate programs, please consult the Graduate School Catalog.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Office, the Research Foundation, the Pinanski Nuclear Center, WLTI, the Research Foundation, the Alumni Memorial Library and the Summer School, the college provides such services to industry and the community as the following:

- Industrial seminars and conferences;
- Technorama, science fair for area high schools;
- Consultive opportunities with administration and faculty;
- Special radio and television programs;
- Collaboration with the Agency for International Development in its foreign aid programs;
- Participation with local and state agencies in the solving of ecological problems.

For information concerning these programs, address the Department of Public Relations at the Institute.

EVENING SCHOOL

The Evening School offers Undergraduate Programs leading to Associate and Baccalaureate Degrees; and part-time Graduate Programs offering a Master's Degree. Satellite programs are provided for area industries. The majority of the degree programs are in the fields of science, engineering technology and business administration. An increasing number of students who have completed an Associated Degree Program on a full-time basis and have become full-time employees are continuing their education on a part-time evening basis in the Baccalaureate Programs.

Additionally, individual subjects in mathematics, science, technology, engineering, business, and general studies may be taken as a special student.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Evening School also offers In-Service Training Programs limited to employees of the Commonwealth and cities and towns within the Commonwealth. These undergraduate programs lead to Associate and B.S. degrees in Civil Engineering Technology, Associate in Business Administration (in either Accounting or Data Processing), and Bachelor in Business Administration. The Associate and B.S. Degree programs in Civil Engineering Technology are accredited by the Engineers' Council for Professional Development.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION

Established in 1950 by the Board of Trustees of the Lowell Technological Institute, the Research Foundation is a not-for-profit organization that does research in a wide variety of fields. The operation is fully self-supporting from income derived from its industrial and government sponsors.

The Research Foundation is housed in a one-story modern building across the Merrimack River from the Institute's main campus. Initially its prime purpose was to answer the needs of the Lowell Technological Institute for facilities and staff to perform basic and applied research in textiles and related subjects. As the Research Foundation expanded, a diverse and growing program of research and development activities increased extensively, and projects have moved into the fields of chemistry,

leather, paper, plastics, electronics, physics, oceanography, nuclear engineering and environmental pollution, in addition to management and economic development assignments.

The Research Foundation is presently composed of five major divisions: Electronics and Physics, Ionospheric Science, Environmental Pollution, Economic Development, as well as a Testing Division.

The Electronics and Physics Division is primarily interested in electronics, electro-mechanical design and development, applied electronics and physics, electro-magnetic interference reduction, power supply technology, and metrology services.

The Ionospheric Science Division is concerned with instrumentation, measurement, data analysis and theoretical studies of the ionosphere and its effect on communications.

The Environmental Pollution Division's areas of interest are air and water pollution sampling and analyses, waste treatability and reuse studies, and plant project design consulting.

The Economic Development Division works in the areas of economic studies, marketing, general management, and manufacturing services.

The Testing Division is mainly concerned with the testing and evaluation of a wide variety of materials submitted by industrial and Government sponsors.

Students are encouraged to visit the Research Foundation.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts 01854.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, student loan program, publishes the official alumni newsletter, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening School senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four executive officers elected by the student body and the officers of each class. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Afro-American Society

This organization assists and organizes whatever separate group and/or function that will allow those individuals dedicated to the benevolent welfare of black people to invest their energies.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Amateur Radio Club

This organization is enjoined to promote the fraternity of Amateur Radio at Lowell Tech and specifically to promote the fellowship of amateur radio through on-the-air activities. To aid interested individuals in obtaining their amateur radio license as well as helping current license holders advance their grades.

Amateur Rocketry Organization

The purpose of this organization is to conduct experiments, research projects and other educational activities designed to increase the knowledge of its membership in the science of modern rocketry and in the technologies related to it.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Archery Club

The purpose of the Archery Club is to promote sportsmanship and accuracy in archery among the student body. Membership is open to all students and faculty at the Institute.

Armenian Students Organization

The purpose and aims of the Armenian Students Organization are to promote, interpret and disseminate on campus the culture, environment, arts and life of Armenia. Members are encouraged to participate more fully in the social and cultural life of the Institute and community. They also render all possible assistance to the newly arriving Armenian students on the campus of Lowell Tech.

Athletics

See College of Extension and General Studies.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier current radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition has extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multipurpose room and radio studios.

WLTI was originally organized as the Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10Kw transmitter. Work is now underway on the renovation of this equipment and the licensing of the station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Bridge Club

The duplicate Bridge Club is open to all students and faculty who are interested in either learning or playing bridge. The club meets every Wednesday in informal session in Eames Lounge and refreshments follow each meeting.

Cadet Advisory Council

The purpose of Cadet Advisory Council is to handle grievances and recommendations concerning actions and policies of the Cadet Corps.

Caligari Cinema Commune

The objectives of this organization are (1) to examine the film as an art from (2) to encourage and support the making of films by Tech students.

Cheerleaders

The Cheerleaders encourage and promote the enthusiasm of the Student Body as well as that of the team members at L.T.I. basketball games.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Student Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interest and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen.

Cricket Club

The purpose of this club is to promote good sportsmanship among the student body by encouraging active participation in this challenging sport.

Current Issues and Affairs Committee

Membership in the society is open to all members of the academic community at Lowell Technological Institute. The objectives of the committee are (1) to provide a forum for the

discussion of current events in the educational, political, social and economic fields, and (2) to establish a vehicle for the implementation of those measures believed essential in the foregoing fields by the majority of the members; all implementation procedures conforming to law and rules and regulations of the Institute.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fencing Club

The Fencing Club makes available to our student body instruction in the fine art of fencing.

Football Club

The purpose of this club is to act as a vehicle to promote the spirit of the academic community by offering the student body organized football.

Fraternities

There are eight fraternities — Delta Kappa Phi, Kappa Sigma, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, Sigma Phi Omicron, Tau Epsilon Phi, and Tau Kappa Epsilon — all have their own fraternity houses. All provide social life off campus and five are national fraternity affiliates. The Inter-fraternity Council fosters the common interests of the seven and sponsors interfraternity social and athletic events.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

Interdormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to ad-

just to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Karate Club

Instruction in Karate is made available to members of this organization.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units. Pershing Rifles maintains a residence which houses several members and is the center of social activity for the organization.

Photography Club

The purpose of this organization is to provide a time, place, and opportunity for members to acquire and discuss photographic techniques, to perform photographic services for other campus organizations, and to exhibit and promote general interest in photographic art.

Pickout

The Pickout is the college yearbook. Its student staff is wholly responsible for the editorial, graphic, and business problems

involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Association for Textile Technology, Student Chapter
- American Chemical Society, Student Chapter
- American Institute of Chemical Engineers, Student Chapter
- American Society of Civil Engineers, Student Chapter
- American Meteorological Society, Student Chapter
- American Nuclear Society, Student Chapter
- American Society of Mechanical Engineers, Student Chapter
- Biology Club
- Institute of Electrical and Electronics Engineers, Student Chapter
- MALTI (Mathematics Association of LTI)
- Society for Advancement of Management, Student Chapter
- Society for Manufacturing Engineers
- Society of Physics Students
- Society of Plastics Engineers, Student Chapter
- TAPPI (Student Chapter, Tech. Association of Pulp & Paper Industry)

Religious Groups

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Service Club

The co-eds at the Institute have formed this organization to be of service to the Institute, and in particular, the athletic department. Some projects undertaken by members are greeting visiting teams, assisting visiting coaches in any way possible, score keeping, time keeping, working with judges. The girls also serve as usherettes, selling programs, etc.

Ski Club

The Ski Club's main purpose is to bring together those interested in the sport of skiing in order to increase the status of the sport at Lowell Technological Institute and also, to set up weekend trips and mainly a semester break skiing trip.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Students International Meditation Society

The purpose of the Students International Meditation Society of Lowell Tech is to help students unfold their latent faculties, develop their creative intelligence to its maximum capacity, and use their full mental potential in studies, sports, and work.

Sororities

BETA TAU Sorority was recently established on campus to promote good fellowship and high scholarship. As a service sorority, BETA TAU participates in many campus and community activities.

PHI SIGMA RHO, established in 1937, is the oldest sorority on campus. Its members enjoy the bonds of sisterhood as well as take an active part in social, civic, and recreational activities.

The activities of PHI SIGMA RHO and BETA TAU are governed by the Interfraternity Sorority Council.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

Colonel Charles L. Vacanti Squadron of the Arnold Air Society

The Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs, charitable works, and aerospace exhibits during the year. Community services include visits to the veterans hospitals, the annual food drive for the needy and the annual blood drive. The Squadron sponsors the annual Military Ball, which is a social highlight of the year.

Varsity Club

Membership is open to anyone who has been a member of a team and participated in the intercollegiate sports program. This organization shall strive to help the student athlete academically. It will be of service in the promotion and development of the intercollegiate athletic program, as well as foster a lasting friendship among the men and women participating in athletics at Lowell Technological Institute.

Veterans Club

The objectives of this club shall be to present programs of interest and importance to the membership of the club, to service all veterans whether or not they are members of the organization, to assist members in finding part-time and summer employment, and to actively participate and become interested in academic and non-academic areas of concern within the Institute.

Women's Tennis Club

The purpose of the Women's Tennis Club is to help improve the tennis competition for all female students at Lowell Technological Institute.

FRATERNITIES

DELTA KAPPA PHI

523 Fletcher Street
Lowell, Massachusetts

Beta Chapter

KAPPA SIGMA

514 E. Merrimack Street
Lowell, Massachusetts

Kappa-XI Chapter

OMICRON PI

31 Waverly Avenue
Lowell, Massachusetts

PHI GAMMA PSI

406 Pawtucket Street
Lowell, Massachusetts

PI LAMBDA PHI

77 Livingstone Avenue
Lowell, Massachusetts

SIGMA PHI OMICRON

105 Eleventh Street
Lowell, Massachusetts

TAU EPSILON PHI

1280 Middlesex Street
Lowell, Massachusetts

TAU KAPPA EPSILON

70 Methuen Street
Lowell, Massachusetts

SORORITIES

BETA TAU

PHI SIGMA RHO

ΦΣΡ

Eta Kappa Nu Association
Epsilon Zeta Chapter

Eta Kappa Nu Association is a national honor society for Electrical Engineering students. The Epsilon Zeta Chapter of Eta Kappa Nu was established on this campus December 12, 1964. It provides an atmosphere for learning, cooperation, human understanding and service, which are so important for the achievement of a full and successful life. The members of Eta Kappa Nu are chosen for their superior academic performance, concern for their fellow students, capacity for hard work and their potential for professional success. These characteristics are evaluated on the basis of the students' academic standing, participation in campus activities, and their outstanding character.

The purpose of this organization is to inspire and to encourage students in electrical engineering to put forth greater effort in the pursuit of knowledge, to use their leadership capabilities and to develop a spirit of cooperation with their fellow students. The organization sponsors an open house in the Electrical Engineering department, conducts EE help classes for underclassmen, introduces prospective students to the physical facilities at L.T.I. and aids the Electrical Engineering department and the school in any way possible.

Who's Who Among Students in
American Colleges and Universities

The basic concept of Who's Who Among Students in American Universities and Colleges is to provide a democratic, national basis for the recognition of outstanding campus leaders. Only college seniors, juniors and graduate students are eligible for nomination. These nominations are submitted annually after selection by campus nominating committees.

Methods for judging the relative merits of various candidates vary widely, although there has been a growing tendency to use an objective point-scale system, to insure fairness in selection. This method is the one currently employed at Tech. The campus committees are instructed by the national organization to consider students whose academic standing, service to the community, leadership in extracurricular activities and future potential are decidedly above average.

All nominations must be endorsed by a member of the faculty and/or administration or other person designated by the college to verify nominations and related matters. Since curricular and extra-curricula programs at various schools vary too greatly to permit accuracy. Each college is assigned a quota of nominees. Tech's quota presently is 33. The quota is carefully calculat-

ed to insure a well-rounded sample of the student body yet it is kept small enough so that nominations are confined to an exceptional group of students.

After the nominations have been submitted to the national office, and approved by it; the individual nominee is notified directly by the organization and is required to submit his or her own biographical data. After the data is received, an entry in the forthcoming edition of the Directory is prepared. At this time a certificate, suitable for framing, is mailed to the student's college for presentation at graduation, an awards ceremony or other appropriate gathering. All the data is then transmitted to the Student Placement Office maintained by the Directory for the benefit of the members.

Since many prospective employers, including such government employers as the Peace Corps, State Department and OCS, look upon the listing in the Directory as an important indicator of future success, the organization has undertaken to provide nominees with a special placement service to assist in making employment contacts and/or supplying recommendations. This service is designated primarily for the student and is performed completely without charge to the employer or the student.

How does Tech judge its applicants for this honor? The following abbreviated point system should give you a good idea.

REQUIREMENTS

Scholastic:

Must have a cumulative average of at least 2.00.
1 pt. for each 1/10 of a pt. over 2.00.
1 pt. for each semester on Dean's List.

Athletics:

2 pts. for each letter received.
2 pts. for being captain of a team.

Extra-curricular:

1 pt. for being a member of club, fraternity, or any other organization.
2 pts. for appointed position in said organization.
3 pts. for elected office except president, editor or co-editor in said organization.

R.O.T.C.:

1 pt. for being a member of band or drill team.
2 pts. for following awards — Sons of American Revolution.

Tau Epsilon Sigma

This society is unique in that it is highly exclusive due to its requirements for acceptance. It is the one society on campus which emphasizes the specific value of high scholastic attainment. Its members, although few in number, include the very successful in life after graduation.

The requirements for membership include a minimum of six consecutive semesters on the Dean's List or the maintenance of a 3.0 or B average over four years with no failures.

Membership in Tau Epsilon Sigma is symbolized by the gold key proudly worn by its members and the reward for scholastic effort with the highest attainment recognized by the Institute.

Chemical Engineering Honor Society

The purpose of the Chemical Engineering Honor Society is to recognize high scholarship, original investigation, professional service in Chemical Engineering, and service contributions to the academic community. Eligibility for membership is a 2.66 semester rating and an overall cumulative rating of at least 2.66 and, of course, being enrolled in the Chemical Engineering curriculum. Members must be in good standing in the LTI Chapter of the American Institute of Chemical Engineers.

A general meeting of the Society will be held each month of the academic year, or a minimum of nine meetings and a minimum of one service function to the academic community must be performed each semester of the school year.

UNDERGRADUATE PROGRAMS

The following are the curricula offered by the various Colleges which are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science.

College of Engineering

Chemical Engineering
Civil Engineering
Electrical Engineering
Industrial Technology
Mechanical Engineering
Plastics Technology

College of Management Science

Business Administration with a major in Accounting, Economics or Management.
Industrial Management

College of Pure and Applied Sciences

Biological Sciences
Chemistry
Mathematics
Meteorology
Nuclear Engineering
Physics
Radiological Health Physics

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students:

A special curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering is open as an In-Service Training Program for employees of the Commonwealth of Massachusetts and its political subdivisions. Regulations for entrance into the program and subjects required prior to attending classes as in-residence students are shown in the Catalogue of the Evening School of the Lowell Technological Institute. A portion of the curriculum is given during the day and is contained in this catalogue under Civil Engineering Technology.

Other baccalaureate degree programs in fields of Technology and Business are given in the Evening School and are described in the Catalogue of the Evening School.

Some undergraduate subjects may be taken for graduate credit. Consult the Graduate School catalogue for details.

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospaces Studies	IT	Industrial Technology
BI	Biological Sciences	LL	Languages and Literature
BA	Business Administration	MA	Mathematics
CN	Chemical Engineering	ME	Mechanical Engineering
CH	Chemistry	MY	Meteorology
CE	Civil Engineering	NU	Nuclear Engineering
DP	Data Processing	PH	Physics
EC	Economics	PL	Plastics
EE	Electrical Engineering	RS	Radiological Sciences
IM	Industrial Management	SS	Social Sciences

Subject Numbers

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., MA-131 is a freshman subject, but MA-411 a senior subject. Subjects in the 500 series are normally for graduate students but may be taken by undergraduates in certain cases with special permission.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites

Prerequisites and restrictions are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Class and Credit Hours

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means two hours of lecture or recitation and six hours of laboratory for four credits; (2-3) (1-6)6 indicates two hours of lecture or recitation and three hours of laboratory for the first semester followed by one hour of lecture or recitation and six hours of laboratory the second semester, for a total of six credits.

FRESHMAN YEAR

Each year approximately 1,000 young men and women enter Lowell Tech as freshman to obtain a quality education in the fields of science, engineering, technology or business administration.

We at Lowell Tech are interested in the student as an "individual" and for this reason several options are available to the entering freshman thus easing the transition from high school to college.

Freshman that.plan to major in a curriculum in the Colleges of Science or Engineering will be assigned to MA-131 College Math I or MA-133 Calculus I according to their mathematical aptitudes and high school records. Students will then have the choice of taking these courses in the conventional lecture-recitation manner or by an alternate "Keller Plan" which is a self-paced, self-study method of learning. MA-101 Mathematical Analysis I will be taken by students majoring in Business Administration or Industrial Technology. Students will be required to attend this class three or four hours per week depending upon their mathematical aptitudes and high school records.

In order to give intellectually able and highly motivated students the richest possible experience, the Physics department and Chemistry department will each offer an Honors Program which is open to students by invitation from the Chairman of each department.

Approximately one-third of the student body entering the College of Management Science will have the option of taking an elective (s) thus postponing taking economics and/or accounting until the sophomore year.

Students are required to take a "Freshman Seminar" during the first semester which will be moderated by a faculty member from the department in which the student intends to specialize. The purpose of the Seminar is to introduce students to elementary concepts of Business Science and Engineering, emphasizing the natural interface these subjects have with the social sciences. Each student will also be assigned an advisor who will be available for consultation on all academic problems.

Students may also receive additional advice and counsel from the Director of Freshman Studies or the Dean of Students. All nonveteran students who are physically qualified must take physical education two hours per week during the entire freshman year.

COLLEGE OF ENGINEERING

COLLEGE OF ENGINEERING

The College of Engineering offers undergraduate programs leading to a Bachelor of Science Degree in Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Industrial Technology and Plastics Technology. For details of Engineering Graduate Programs see the Graduate Catalogue.

Broadly defined, engineering is a profession which seeks to apply scientific knowledge for the improvement of society. Because of the vastly varied needs of society and differences in individual talent and motivation, a wide spectrum of engineering education programs have been developed in the United States. On one extreme of this spectrum are highly analytical programs which place a strong demand on the student's ability to deal in abstract mathematical terms. Programs in this area are often called Engineering Science. On the other extreme are programs that are related to specific areas of application and therefore place greater emphasis on descriptive knowledge rather than mathematical skills. Programs in this area are generally called Engineering Technology or Technology. In order to best serve the needs of its student body the College of Engineering offers programs distributed within this wide spectrum. Although the emphasis within each program is specific and technical, each program has the educational breadth that distinguishes the professional from the technician.

As distinguished from the pure scientist who generally works on basic research, the engineer is generally a practitioner. As a practitioner the engineer must be able to identify problems, creatively design solutions, build and implement. In the practice of the profession, the engineer will be called on to combine knowledge of science, mathematics, and "state of the art" with judgment based on experience in order to develop economic and socially acceptable ways to use the available resources for the benefit of mankind. The professional is constantly searching for a better way, a better design, a more imaginative and effective system.

The educational objective of the College of Engineering is to prepare students for entrance into the profession of engineering. In recognition of the variety of professional activities involved, the programs have been designed to allow students to elect to enter the practice of engineering after completion of an undergraduate degree or to delay entrance until they have obtained a graduate degree. Faculty advisors are assigned to each student in order to provide experienced guidance to the student in the selection of his particular program.

FACULTY

William T. Hogan, B.S., S.M., D. Sc., P.E., Dean

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Roger H. Baumann, B.S., M.S., Sc.D., Electrical Engineering

Russell W. Ehlers, B.S., M.A., Ph.D., Plastics Technology

Bartlett W. Paulding, Jr., Geol. Engr., Ph.D., P.E., Civil Engineering

Howard H. Reynolds, A.B., Sc.D., P.E., Chemical Engineering

G. Dudley Shepard, B.S., M.S., Sc.D., Mechanical Engineering

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C. Zelman Kamien, B.S., M.S., Ph.D. (Purdue University), Associate Professor.

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Plastics Technology

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Mr. Thomas Conlon, Contour Chemical Company
Mr. Joseph C. Day, '66, General Electric Company, Plastics Department
Mr. Neil Flathers, Eastern New England-Society of Plastics Engineers
Mr. Iver Freeman, Reed-Prentice Company
Mr. Richard Ingraham, Albany International Corporation
Mr. John Kuc '73, Lowell Technological Institute
Mr. Ralph Mondano, Custom Materials, Incorporated
Mr. Jeffrey Monti '74, Lowell Technological Institute
Mr. Marvin Olim '75, Lowell Technological Institute
Mr. Joseph Rich '69, Mobay Chemical Company
Mr. D.V. Rosato, Ingersoll-Rand Corporation
Mr. Saul Perlman '60, Enjay Chemical Company
Mr. Robert J. Pierotti '69, Graduate School, Lowell Technological Institute

CHEMICAL ENGINEERING

Chemical Engineering is the only engineering discipline based on the science of chemistry, although it has broad roots in the other scientific disciplines as well. It concerns itself with chemical reactions, reaction kinetics and equilibrium and mass and energy transport.

Although the chemical engineer traditionally has entered the chemical and allied industries, the broad base of the chemical engineering discipline has tended to attract chemical engineers into other fields such as management, environmental protection, bio-chemical engineering and engineering applications to life sciences. The basic concepts of unit operations and unit processes, originally developed by chemical engineers, have proved to be of immense value in a wide spectrum of applications.

The chemical process industry and allied industries such as plastics and packaging have provided a strong and continued growth and an ever-increasing demand for chemical engineering graduates. Current shortages of chemical engineers are expected to persist for many years to come. The stability and dynamic growth of these industries has opened up unparalleled challenges and growth prospects for the chemical engineer.

Because of the importance of the paper industry as a segment of the chemical industry, this curriculum provides the opportunity for the student to obtain the degree of "Bachelor of Science in Chemical Engineering With Option in Paper Engineering." To take this option he must elect to take 5 Paper Engineering courses in his senior year. A number of $500 per year scholarships are available to students choosing this option.

The curriculum provides maximum flexibility and allows for individual and original research if the student wishes. Considerable emphasis is placed on oral and written expressions so necessary in the business world; plant trips are provided to give the essential link between theory and practice. Summer jobs in the chemical industry are fostered and some financial assistance is available to the student.

This broad chemical and engineering training offers the graduate of the curriculum opportunities to enter research and development, production, sales, marketing, and general management, or he may elect to enter graduate school upon graduation.

This curriculum is accredited by the Engineers' Council for Professional Development (ECPD).

CHEMICAL ENGINEERING PROGRAM

FRESHMAN YEAR

First Semester

CH	121*	Chemistry	(3-0)3
CH	123	Chemistry Lab	(0-3)1
LL	111	English	(3-0)3
MA	131		
or			
MA	133	Col. Math I or Calculus I	(4-0)4
PH	141*	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)_
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

CH	126*	Chemistry	(3-0)3
CH	124	Chemistry Lab	(0-3)1
LL	112	English	(3-0)3
MA	132		
or			
MA	134	Col. Math II or Calculus II	(4-0)4
PH	144*	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

CH	223	Organic Chemistry	(3-3)4
CN	203	Introduction to Chemical Engineering	(3-0)3
CN	207	Computer Programming for Chemical Engineers	(0-3)1
MA	231	College Math III	(4-0)4
or			
MA	233	Calculus III	(3-0)3
ME	201	Graphics	(0-3)1
ME	215	Analytic Mechanics I	(3-0)3
		Humanistic - Social Elective	(3-0)3
		Total Hours	(15-9)18 or (16-9)19

Second Semester

CH	224	Organic Chemistry	(3-0)3
CN	204	Chemical Engineering Calculations	(3-0)3
CN	206	Fluid Mechanics	(2-3)3
MA	232	College Math IV	(4-0)4
or			
MA	234	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(17-3)18 or (18-3)19

JUNIOR YEAR

First Semester

CN	305	Heat Transfer	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
CN	315	Unit Operations Laboratory I	(0-3)1
EE	348	Electrical Engineering Concepts	(3-0)3
MA	301	Adv. Calculus for Applications	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(15-3)16

Second Semester

CH	336	Principles of Physical Chemistry	(3-0)3
CH	338	Princ. of Phys. Chem. Lab	(0-3)1
CN	306	Transport Phenomena	(3-0)3
CN	310	Separation Processes	(3-0)3
CN	316	Unit Operations Laboratory II	(0-3)1
CN	408	Engineering Materials	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(15-6)17

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	409	Economics and Process Analysis	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective	(3-0)3
		Humanistic-Social Elective*	(3-0)3
		Total Hours	(15-0)15

*ROTC may elect AS 401

Second Semester

CN	410	Plant Design	(3-0)3
CN	414	Process Dynamics and Control	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective	(3-0)3
		Humanistic-Social Elective*	(3-0)3
		Total Hours	(15-0)15

*ROTC may elect AS 402

Students electing the Option in Paper Engineering will take the following courses in their senior year as their Technical Electives:

CN	401	Paper Industry Process Analysis	(3-0)3
CN	402	Eng. Anal. of Coating and Converting Systems	(2-3)3
CN	404	Process Calculations of Pulp and Paper Processes	(3-0)3
CN	405	Design of Papers	(3-3)4
CN	419	Special Projects	(0-3)1

CHEMICAL ENGINEERING COURSE DESCRIPTIONS

CN 203 Introduction to Chemical Engineering (3-0)3
[CH 126 or CH 128, MA 132 or MA 134]

Introduction to the field of chemical engineering. Units and dimensions used by engineers. Flow sheets. P-V-T relationships and the Gas Laws. Introduction to mass balances.

CN 204 Chemical Engineering Calculations (3-0)3
[CN 203, MA 231 or MA 233]

Mass and Energy balances, including phase separation and elementary thermochemistry. Steady-state calculations and applications to chemical engineering processes. Introduction to unsteady-state concepts.

CN 206 Fluid Mechanics (2-3)3
[CN 203]

Introduction to fluid statics and application of fluid mechanics principles to the analysis and design of fluid systems. Design of fluid meters and conduits. Friction factor, pressure drops in laminar and turbulent flow and the introduction to boundary layer theory.

Laboratory work involves calculating devices, including Wang Calculator, library investigations, fluids flow laboratory, chemical engineering equipment and its use, and technical report writing.

CN 207 Computer Programming for Chemical Engineers (0-3)1

Programming principles of the FORTRAN language applied to Chemical Engineering problems, including input output statements, looping, testing, subroutines, and advanced state of the art techniques. Ten problems will be individually handled by each student on the CDC 3100 or other Institute computer facilities.

CN 305 Heat Transfer (3-0)3
[CN 206, MA 232 or MA 234]

Fundamental principles of heat transmission by conduction, convection, radiation and evaporation. Application of these principles to the solution of industrial heat transfer problems and to the preliminary design of heat exchange equipment including evaporators.

CN 306 Transport Phenomena (3-0)3
[CN 306, MA 301]

Introduction to the theory of the momentum, energy and mass transfer. Integral and differential approaches. Macroscopic

and microscopic balances. Application of the macroscopic balances to the solution of practical problems in chemical industry.

CN 310 Separation Processes (3-0)3
[CN 305; CN 306 taken concurrently]

Introduction to the design of multicomponent stage processes, such as distillation, absorption, extraction and humidification.

CN 311 Chemical Engineering Thermodynamics I (3-0)3
[CN 305 taken concurrently]

Application of the First and Second Laws of Thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 312 Chemical Engineering Thermodynamics II (3-0)3
[CN 311]

A detailed rigorous treatment of topics not covered in CN 311. Additional material on general thermodynamic relations are developed for use in application of non-ideal gases and real substances. Interpretation of phase equilibrium data and applications are covered, as well as an introduction to statistical thermodynamics.

CN 315-316 Chemical Engineering Laboratory (0-3) (0-3)2
[CN 305 and CN 306 taken concurrently]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports. Application of chemical engineering principles.

CN 319 Special Projects Credits to be arranged
[Approval of Instructor]

Research projects to be undertaken by the student with the supervision of a staff member. Usually will be an original problem. Reports required on project work.

CN 401 Paper Industry Process Analysis (3-0)3

Lectures dealing with processes of fiber separation from raw materials, fiber purification, mechanical processing of fiber and sheet formation. Chemical Engineering theory is applied to the analysis of these operations.

CN 402 Engineering Analysis of Coating and Converting Systems (2-3)3

Lectures and problems concerned with the engineering design, technology and economics of paper and paperboard processes. Rheology and engineering properties of coating materials. Mechanical processes, coating, impregnating, laminating and printing processes are discussed in detail.

CN 403 **Reactor Design and Kinetics** **(3-0)3**
[CN 306]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems. May be taken for graduate credit.

CN 404 **Process Calculations of Pulp and Paper Processes** **(3-0)3**

Mathematical analysis of various processes using energy and material balances. Application of theory to the design of paper of various structure and properties.

CN 405 **Design of Papers** **(3-3)4**

Fundamentals of the mechanical and optical testing of paper and allied products. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of test data. Structure of materials revealed by physical tests. Laboratory projects designed to illustrate problems in design of pulps and paper.

CN 408 **Engineering Materials** **(3-0)3**
[Approval of Instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures. Corrosion and elementary electrochemistry. Structures of metals, non metals, and polymeric materials. Structure of materials related to performance. May be taken for graduate credit.

CN 409 **Economics and Process Analysis** **(3-0)3**
[CN 304, MA 232 or MA 234]

Analysis of selected chemical processes from the overall view of chemical engineering technology and basic economics. Time value of money concept. Methods of depreciation. Factors of cost in (a) plant design, (b) plant operation. Term problems involving computer-based solutions.

CN 410 **Plant Design** **(3-0)3**
[CN 409]

Application of unit operations; economics and process analysis in the design of complete chemical plants. Flow sheets, specifications for equipment and an economic estimate of the total plant cost is required for successful completion of the course.

CN 414 **Process Dynamics and Control** **(3-0)3**
[CN 204, CN 301]

An introduction to chemical process control, description of processes and equipment by differential equations and the La-

Place transform. Representation of open and closed loop by block diagrams. Control loop stability is discussed together with methods of representing dynamic behavior on Bode and Nyquist diagrams and related to experimental data. May be taken for graduate credit.

CN 419 Special Senior Projects Credits to be Arranged

[Approval of Instructor]

Original research projects primarily in the chemical engineering field and supervised by a staff member of the Department. Reports required on work done.

CN 420 Analog Computer Techniques (3-0)3

[MA 301]

Application of analog computer concepts in the solution of chemical engineering and process dynamics problems. Use of the Department's EAI 380 analog computer is emphasized.

CN 422 Case Studies in Chemical Engineering (3-0)3

Discussion of a number of chemical engineering processes from the standpoint of engineering theory and reduction to practice. Plant visits will be used to illustrate real-life engineering solutions. Oral and written reports required.

CN 424 Chemical Process Industries Analysis (3-0)3

An over-view of the Chemical Process Industries illustrating their interrelationships and interaction with other industries. Selected processes will be studied in detail to illustrate processing problems, alternative raw materials, economics of processes and marketing problems.

CN 430 Entrepreneurship in Engineering (3-0)3

This course is designed to introduce the student to the important field of the engineer entrepreneur. Actual problems are developed showing how the inception of an idea through the commercial development of a product or service is carried out. The technical feasibility and economic validity of products and processes are studied in depth. Real-life cases will be examined by the methodology developed in the course.

CN 503 Absorption and Extraction (3-0)3

[MA 301]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems. Use of computer in some problem solutions.

CN 506 Colloid Chemistry for Chemical Engineers (3-0)3

Colloid chemistry principles applied to chemical engineering processes. Zeta potential and its applications; special problems involving surface chemistry and physics.

CN 507 Corrosion and Electrochemical Principles (2-0)2

Electrochemical principles and physical chemistry relating to corrosion of metals. Materials of construction and design based on these principles. Prediction of metal behavior in process design.

CIVIL ENGINEERING

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and processing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes;and the adaption of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are Civil Engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

CIVIL ENGINEERING PROGRAM

FRESHMAN YEAR

First Semester

CH	121*	Chemistry	(3-0)3
CH	123	Chemistry Lab	(0-3)1
L	111	English	(3-0)3
MA	131		
r			
MA	133	Col. Math I or Calculus I	(4-0)4
H	141*	Physics	(3-1)3
S	001	Frosh Seminar	(1-0)-
E	101	Physical Education	(0-2)1
		Total hours	(14-6)15

CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

CH	126*	Chemistry	(3-0)3
CH	124	Chemistry Lab	(0-3)1
LL	112	English	(3-0)3
MA	132		
or			
MA	134	Col. Math II or Calculus II	(4-0)4
PH	144*	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

CE	220	Surveying I	(3-4)4
MA	231	College Math III	(4-0)4
or			
MA	233	Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	201	Graphics	(0-3)1
ME	211	Mechanics I	(3-0)3
PH	245*	Physics	(4-1)4
		Total hours	(15-8)17 or (16-8)18

*PH 247 Honors Physics may be substituted

Second Semester

CE	221	Surveying II	(3-4)4
LL	210	Technical & Scientific Communication	(3-0)3
MA	232	College Math IV	(4-0)4
or			
MA	234	Calculus IV	(3-0)3
MA	362	Numerical Analysis	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
		Total hours	(15-4)17 or (16-4)18

JUNIOR YEAR

First Semester

CE	310	Engineering Materials	(2-3)3
CE	350	Structural Analysis	(3-3)4
EC	201	Economics I	(3-0)3
ME	309	Dynamics I	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total hours	(14-6)16

Second Semester

CE	301	Hydraulics	(3-3)4
CE	340	Transportation	(4-0)4
CE	351	Structural Design I	(3-3)4
EC	202	Economics II	(3-0)3
ME	347	Elements of Thermodynamics & Heat Transfer	(3-0)3
		Total hours	(16-6)18

SENIOR YEAR

First Semester

CE	430	Soil Mechanics I	(3-0)3
CE	460	Water Resources Engineering	(3-3)4
EE	348	Basic Electrical Engineering Concepts	(3-0)3
		Humanistic-Social Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	16

*ROTC Students may elect AS 401

Second Semester

CE	431	Foundation & Soil Engineering	(3-3)4
EC	414	Engineering Economy	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
		Humanistic-Social Elective	(3-0)3
		Humanistic-Social Elective*	(3-0)3
		Technical Elective	3
		Total credit hours	17

*ROTC Students may elect AS 402

CIVIL ENGINEERING TECHNOLOGY

The following curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering Technology is available only to employees of the Commonwealth of Massachusetts and its political subdivisions as an In-Service Training Program. For regulations concerning this program and for subjects required prior to the following curriculum, consult the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

This curriculum is accredited by the Engineers' Council for Professional Development.

CIVIL ENGINEERING TECHNOLOGY PROGRAM

JUNIOR YEAR

Second Semester

CE	961	Advanced Surveying	(2-1)2
CE	971	Structures	(2-1)2
DP	930	Scientific Computer Programming-FORTRAN	(2-1)2
LL	962	American Literature	(3-0)3
PH	942	Physics	(3-2)4
		Humanistic-Social Elective	(3-0)3
		Total hours	(15-5)16

SENIOR YEAR

First Semester

CE	991	Concrete Analysis and Design	(3-3)4
CE	992	Soil Mechanics	(3-3)4
CE	995	Engineering Laboratory	(0-3)1
EE	975	Basic Electricity	(3-3)4
		Humanistic-Social Elective	(3-0)3
		Total hours	(12-12)16

Second Semester

CE	981	Structural Analysis & Design	(3-3)4
CE	982	Hydrology	(3-3)4
CE	994	Engineering Problems	(2-1)2
EC	414	Engineering Economy	(3-0)3
EE	978	Basic Electronics	(3-0)3
		Total hours	(14-7)16

CE 220 **Surveying I** **(3-4)4**
[Formerly CE 201]
[MA 131 or MA 133, ME 201 concurrently]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 221 **Surveying II** **(3-4)4**
[Formerly CE 202]
[CE 220]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering.

CE 301 **Hydraulics** **(4-0)4**
[Formerly CE 322]
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits, as well as through turbomachinery. An introduction to the basic concepts of hydrodynamics, hydraulic similitude and dimensional analysis.

CE 310 **Engineering Materials** **(2-3)3**
[Formerly CE 311]
[CH 126 or CH 128]

A treatment of the properties of engineering materials as such influence the design, construction and maintenance of Civil Engineering works. Included are such materials as ferrous and non-ferrous metals, timber, plastics, and cementitious materials. Also includes the description and identification of soils. Supplemented by laboratory testing of various engineering materials.

CE 340 **Transportation** **(3-3)4**
[Formerly CE 342]
[CE 221, CE 310]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic and materials of construction.

CE 350 **Structural Analysis** **(3-3)4**

[Formerly CE 313]

[ME 220]

Principles of structural analysis applied to typical civil engineering structures as the initial step in the total design concept. Basic emphasis on the analysis of statistically determinate structures with elements of modern methods of analysis of indeterminate structures. The digital computer as an analytical tool.

CE 351 **Structural Design I** **(3-3)4**

[Formerly CE 314]

[CE 310, CE 350]

An introduction to the fundamentals of the design of reinforced concrete, metal and timber structures. Both elastic and inelastic methods are used to design structural elements. Included are tension members, compression members, structural joints, floor systems, and footings.

CE 430 **Soil Mechanics** **(3-0)3**

[Formerly CE 431]

[ME 220, CE 310]

Development of the fundamental principles of the science of soil mechanics as utilized in soil and foundation engineering. Includes index properties, classification, strength and deformation properties, and hydraulic properties which are required for foundation and soil engineering design.

CE 431 **Foundation & Soil Engineering** **(3-3)4**

[Formerly CE 432]

[CE 430]

The application of soil mechanics to the design and analysis of foundations and soil structures. Includes slope stability analysis and the design of retaining structures, deep and shallow foundations, and the bracing of excavations. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties.

CE 440 **Transportation Planning** **(3-0)3**

[Formerly CE 441]

[CE 340]

The principles and techniques involved in the various stages of comprehensive planning of transportation facilities. Preliminary engineering studies of route locations aided by use of aerial photographs and with full accountability of environmental influences. Includes the basic concepts of transportation economics, finance and administration.

CE 441 Transportation Systems (2-3)3
[Formerly CE 442]
[CE 340]

The application of systems approach to problem solving in transportation engineering. The basic concept in systemization; the components, the classification, operational factors, and its application to planning. Special attention to terminals and traffic systems.

CE 450 Advanced Structural Analysis (3-0)3
[CE 350]

Classical and matrix methods of structural analysis applied to complex plane frames. Elementary space truss analysis. Elementary model analysis through the use of influence lines for indeterminate structures. The digital computer and problem oriented languages as analytical tools.

CE 451 Structural Design II (2-3)3
[CE 351, CE 450]

A study of the design and construction of modern structures for students majoring in structural engineering. Emphasis is placed on special projects, case studies, and the use of the digital computer. Special topics included are torsion of non-circular members, prestressed concrete, beam-columns, yield line theory, design of flat slabs, and elementary shell structures.

CE 460 Water Resources Engineering (3-3)4
[Formerly CE 421]
[CE 301]

The origins of rainfall and snow melt are studied with respect to flow over and through the land for flood control and water resource purposes. Probability concepts establish optimal criteria for dam and reservoir feasibility. Peak flows are determined by statistics and by hydrograph techniques.

CE 462 Sanitary Engineering I (3-0)3
[Formerly CE 451]
[CE 301]

Physical, chemical, and biological principles of the treatment of water and sewage are considered along with their application to treatment systems. The several system components of water and sewage treatment plants are studied to provide a basis for design capability.

CE 463 Sanitary Engineering II (2-3)3
[Formerly CE 452]
[CE 301, CE 460]

Presents basic principles of design of water supply and waste

water systems with emphasis on determination of design flows and system performance. The laboratory will present fundamental tests and analytic procedures essential to sanitary engineering design and practice.

CE 480 Special Topics in Civil Engineering (2-3)3
[Senior Status]

Relevant civil engineering projects selected to synthesize the planning, analysis and design aspects of engineering problems. Results presented as technical reports.

CE 961 Advanced Surveying (2-1)2
[45.32]
[For students in Engineering Technology only]

Application of higher surveying techniques to the providing of information and the solution of engineering problems. Topics covered include precise measurement of distances; precision measurement of angles; methods of determining elevations with high precision; consideration of photogrammetric techniques; and the basic principles of engineering astronomy.

CE 971 Structures (2-1)2
[25.52]
[For students in Engineering Technology only]

Review of elementary analysis of determinate structures with applications to more complex structures. Influence lines and their applications. Calculation of deflections of beams, frames and trusses. The analysis of indeterminate beams, trusses and simple frames by currently applicable methods.

CE 981 Structural Analysis and Design (3-3)4
[CE 971, 45.52]
[For students in Engineering Technology only]

Analysis and design of beams and frames. Design of structural elements under typical stresses by use of current design codes.

CE 982 Hydrology (3-3)4
[25.46]
[For students in Engineering Technology only]

A practical treatment of the occurrence and distribution of rainfall, surface and groundwater flow. Use of hydrologic factors as components in the design of hydraulic structures.

CE 991 Concrete Analysis and Design (3-3)4
[25.53]
[For students in Engineering Technology only]

The review and extension of the application of current methods to the analysis and design of reinforced concrete structures Use of design aids to facilitate the solution of selected problems.

CE 992 **Soil Mechanics** **(3-3)4**

[CE 971]

[For students in Engineering Technology only]

Introduction to soil mechanics including laboratory techniques, all with the emphasis on the application of principles. Encompasses the use of field and laboratory tests in the design of foundations and the treatment of highway embankments. Laboratory work includes soil classification, graduation tests, Atterberg limits, and the common soil strength and compressibility tests.

CE 994 **Engineering Problems** **(2-1)2**

[For students in Engineering Technology only]

Topical discussions covering the relationship of the engineer to such groups as the general public, governmental agencies, clients and contractors, legal entities, and other engineers. Case studies include engineering concerns in such areas as contracts and specifications, regulatory agencies including zoning boards, boards of appeals, and conservation agencies.

CE 995 **Engineering Laboratory** **(0-3)1**

[CE 971]

[For students in Engineering Technology only]

Introduction to the basic techniques in the testing of engineering materials to establish experimentally the basic stress and strain indices. Introduction to experimental stress analysis by laboratory methods.

NOTE: All numerical prerequisites will be found in the catalogue of the Division of Evening Studies.

ELECTRICAL ENGINEERING

The objective of this curriculum is to provide the student with a sound foundation for a professional career in electrical engineering, which is accredited by the Engineer's Council for Professional Development (ECPD). The degree awarded after four years of study is a Bachelor of Science in Electrical Engineering.

Master of Science degrees in Electrical Engineering, Computer Engineering, and Systems Engineering are also offered by the department. These programs are fully described in the Graduate School Catalogue, but graduate course descriptions are included in this bulletin for the benefit of well-qualified undergraduates.

Electrical Engineering is a dynamic field, receiving much of its stimulus from contemporary breakthroughs in the pure sciences. Because new concepts and developments are continuously entering the engineering disciplines, the viable engineering education cannot be limited to the acquisition of specific skills and methods but must provide the student with a deep understanding of his field, while anticipating his future needs.

Hence, students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classrooms. Specialization at the undergraduate level is, in general, discouraged. Interdisciplinary study is fostered by a relatively flexible elective system.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life.

Many of the courses required in the Electrical Engineering curriculum are heavily dependent upon mathematical techniques. It is therefore recommended that a freshman seeking admission into the sophomore year of Electrical Engineering should have received grades of not less than C− in all freshman mathematics and physics courses.

ELECTRICAL ENGINEERING PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Lab	(0-3)1
LL	111	English	(3-0)3
MA	131		
or			
MA	133	Col. Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)-
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted.

Second Semester

*CH	122	Chemistry	(3-0)3
CH	124	Chemistry Lab	(0-3)1
LL	112	English	(3-0)3
MA	132		
or			
MA	134	Col. Math II or Calculus II	(4-0)4
*PH	144	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory I	(4-0)4
EE	207	Basic Electrical Engineering Laboratory I	(1-3)2
MA	231	Col. Math III	(4-0)4
or			
MA	233	Calculus III	(3-0)3
*PH	245	Physics	(4-1)4
		Total Hours	(16-4)17 or (15-4)16

*PH 247 Honors Physics may be substituted.

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory II	(4-0)4
EE	208	Basic Electrical Engineering Laboratory II	(1-3)2
MA	232	Col. Math III	(4-0)4
or			
MA	234	Calculus IV	(3-0)3
ME	212	Introductory Mechanics	(4-0)4
		Total Hours	(16-3)17 or (15-3)16

JUNIOR YEAR

First Semester

EE	311	Electronics Laboratory I	(1-3)2
EE	327	Programming and Application of Digital Computers I	(2-0)2
EE	355	Introductory Electromechanics	(3-0)3
or			
EE	362	Signal and System Analysis	(3-0)3
EE	365	Electronics I	(3-0)3
MA	315	Complex Variables for Engineers	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(15-3)16

Second Semester

EE	312	Electronics Laboratory II	(1-3)2
EE	328	Programming and Application of Digital Computers II	(2-0)2
EE	360	Electromagnetic Theory I	(3-0)3
EE	362	Signal and System Analysis	(3-0)3
or			
EE	355	Introductory Electromechanics	(3-0)3
EE	366	Electronics II	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(15-3)16

SENIOR YEAR

First Semester

EE	413	Linear Feedback Systems	(3-0)3
or:		Technical Elective	3
EE	461	Electromagnetic Theory II	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		Free Elective	3
		Humanistic-Social Elective*	(3-0)3
		Total Hours	15

*ROTC students may elect AS 402 for three hours.

Second Semester

		Technical Elective	(3-0)3
or			
EE	413	Linear Feedback Systems	(3-0)3
		Technical Electives	6
		Free Elective	3
		Humanistic-Social Elective*	(3-0)3
		Total Hours	15

*ROTC students may elect AS 402 for three hours.

Humanistic-Social Electives

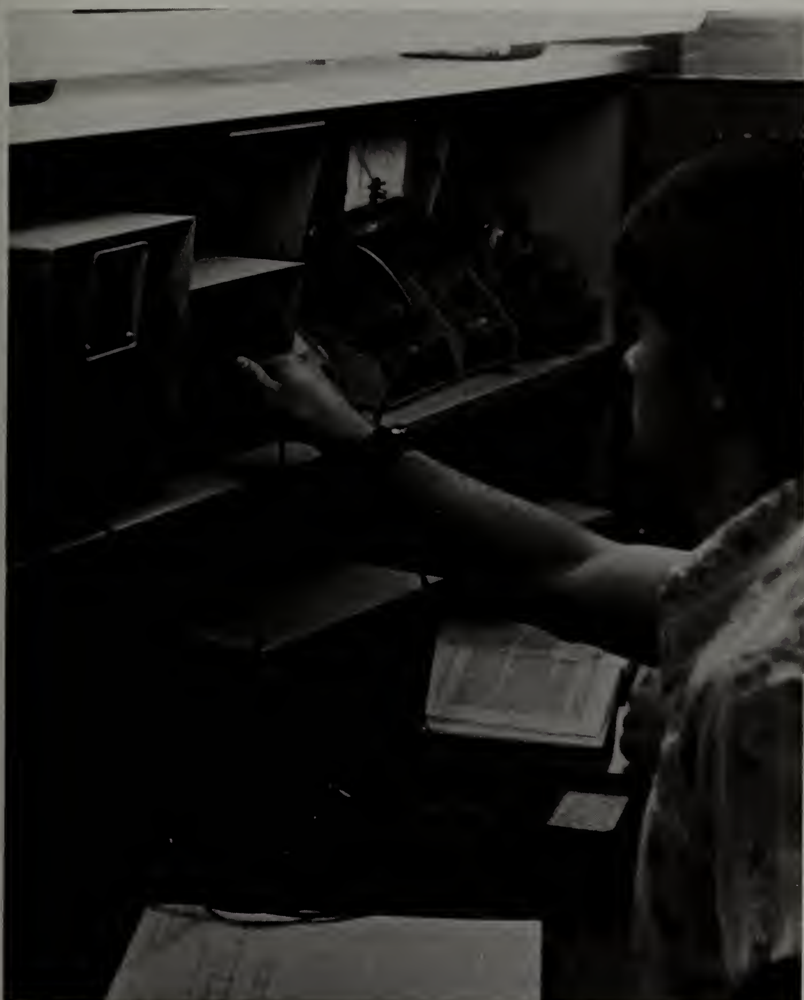
These electives are to be picked from LL and SS subjects. However, economics courses EC 201-202 (required courses) also fall in this category. Advanced economics or business courses can only be taken as Free Electives. Elementary languages must be taken for two terms for Humanistic-Social elective credit.

Technical Electives

These electives are normally 400 level EE courses. However, with the approval of the student's academic advisor, any scientific subjects (up to 6 credits) may be taken from the College of Engineering or from the College of Pure and Applied Sciences.

Free Electives

These electives may be picked from all Colleges at LTI or from courses at Lowell State upon approval of the student's academic advisor.



ELECTRICAL ENGINEERING COURSE DESCRIPTIONS

EE 201 Introductory Circuit Theory I (4-0)4
[MA 132 or MA 134; PH 245 concurrently]

Terminal characteristics of ideal elements, active and passive. Ohm's Law and Kirchhoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis. Definition and consequences of linearity, superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits, Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics, energy relations, graphical differentiation and integration. First-order transients: initial conditions, natural response and natural frequencies. Network response to unit step function and unit impulse. Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane.

EE 202 Introductory Circuit Theory II (4-0)4
[EE 201]

Sinusoidal forcing function, complex numbers, phasors, sinusoidal steadystate. Average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton's theorems, superposition, reciprocity, maximum power and Tellegen's theorem in the frequency domain. Magnetic coupling, mutual inductance, ideal transformer. Impedance and admittance and hybrid parameters for a two-port network. Introduction to matrices and their use in circuit analysis.

EE 207 Basic Electrical Engineering Laboratory I (1-3)2
[EE 201 concurrently]

Experimental work designed to verify theory and to acquaint students with electrical measurement techniques: experiments on dc meters, bridges, and oscilloscopes. Remainder of experiments are correlated with course EE 201 and concern: resistive measurements, Kirchhoff's Laws, network theorems, conservation of power and maximum power transfer, inductance and capacitance, and first and second-order transients.

EE 208 Basic Electrical Engineering Laboratory II (1-3)2
[EE 207, EE 202 concurrently]

Experimental work, designed to emphasize electrical measurement techniques of linear systems with time-varying signals.

Waveform measurements with dc and ac meters as well as advanced use of the oscilloscope with experiments integrated with course EE 202. Experiments concern: Kirchhoff's Laws for phasors, magnitude and phase measurements of impedance, network theorems, frequency response, resonance, inductance and transformers, and maximum power transfer.

EE 211 Fundamentals of Electricity (3-0)3
[MA 132 or MA 134; PH 245 concurrently]
[Not open to students majoring in Electrical Engineering]

An introduction to electric circuits. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state ac circuits, two-terminal networks, and two terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]
[Not open to students majoring in Electrical Engineering]

A background subject in electronics presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211 or EE 348 concurrently]
[Not open to students majoring in Electrical Engineering]

An introductory laboratory course primarily devoted to basic measurement techniques and investigation of terminal characteristics of typical electrical machinery.

EE 311 Electronics Laboratory I (1-3)2
[EE 365 concurrently]

A laboratory course which explores the use of dual trace and differential amplifiers as oscilliscope plug-in units and other electronic test equipment in the investigation of static and dynamic characteristics of the vacuum triode, the solid state diode, and the bipolar transitor. In addition experiments in solid-state physics are performed. The experiments in this course are closely coordinated with the subject material in course EE 365.

EE 312 Electronics Laboratory II (1-3)2
[EE 366 concurrently]

The laboratory experiments in this course are closely coordinated with the subject material in course EE 366. Experiments covering the following subject areas are performed: biasing configurations and stability for bipolar transistors, single stage bipolar and field effect transitor amplifiers, differential amplifiers, feedback amplifiers, and linear integrated circuits.

EE 327 Programming and Application of Digital Computers I (2-0)2

[EE 202]

Elementary computer organization and information flow concepts are developed. Number systems are reviewed with emphasis on binary addition and subtraction. The theme of problem interpretation and analysis is stressed through program flow charting, coding, and documentation. FORGO and FORTRAN II-D programming languages are used to solve problems involving numerical integration, series solutions, list sorting, array manipulation, and elementary matrix operations. The interpretation and verification of computer results are stressed.

EE 328 Programming and Application of Digital Computers II (2-0)2

[EE 327]

The Boolean representation and the hardware implementation of the basic logical operations, half-adders and full-adders are developed. An introduction to programming techniques required in the development of large programs with emphasis on user-developed main programs that link disk-stored subprograms. Topics include definite and indefinite numerical integration, piecewise-linear function generation, first-order linear and nonlinear differential equations, simultaneous equations with real variables, determination of the magnitude and phase of rational functions, time-domain and frequency-domain plots.

EE 348 Basic Electrical Engineering Concepts (3-0)3

[MA 132 or MA 134]

[Not open to students majoring in Electrical Engineering]

An introduction to the basic principles of electricity, including the concept of voltage, current, resistance, inductance and capacitance; Ohm's and Kirchhoff's Laws; Thevenin's and Norton's Theorems. Other areas of coverages will include sinusoidal steady state analysis of RLC circuits, motor and generator concepts and an introduction to solid state devices including the semiconductor diode and transistor.

EE 351 Industrial Electronics (3-0)3

[MA 132 or MA 134]

[Not open to students majoring in Electrical Engineering]

The principles of alternating currents and direct current as a background for the understanding of electronic circuits. The elements of logic circuits, amplifiers, and power supplies. Industrial control circuits and rotating machines.

EE 355 Introductory Electromechanics (3-0)3

[EE 202]

Introduction to magnetic circuits, transformer equivalent circuits. Singly and multiply excited energy conversion devices. A.C.-D.C. rotating machines.

EE 360 — Electromagnetic Theory I — (3-0)3
[MA 232 or MA 234]

An intermediate course in electrostatics and magnetostatics using vector calculus. Topics include: the electric field, line and surface integrals, potential, the divergence theorem, Gauss law, capacitance, conductors, dielectrics, Poisson's and Laplace's equations, the Biot-Savart law, Stokes's theorem, scalar and vector magnetic potentials, force and torque on conductors, magnetic circuits and inductance.

EE 362 — Signal and System Analysis — (3-0)3
[EE 202, MA 232 or MA 234]

Natural and forced response of linear systems; exponential excitation, impulse response, and system function. Fourier series analysis, impulse method of coefficient evaluation. Fourier transforms, complex Fourier transforms and Laplace transforms applied to linear systems analysis. Paley-Wiener criterion and causality. Distortionless ideal filters. Time-convolution in linear systems.

EE 365 — Electronics I — (3-0)3
[PH 245, EE 202]

A brief introduction to solid state physics leading to discussion of junction diode characteristics, diode applications, BJT characteristics, and digital circuits including the analysis of TTL gates. The small signal, low freq. models of the BJT and the operation of FET devices are also discussed.

EE 366 — Electronics II — (3-0)3
[EE 365]

A continuation of EE 365 with discussions and analysis of multistage amplifiers, feedback amplifiers and oscillators using both FET and BJT devices. The accumulated knowledge of basic electronic building blocks is then applied in the study of modern analog, digital and power systems.

EE 403 — Microwave Design Theory — (3-0)3
[EE 461]

An introductory course in the analysis and design of passive microwave devices beginning with a review of time-varying electromagnetic field concepts and transmission lines. Impedance matching techniques, terminations, attenuators, phase changers, directional couplers, hybrids. Microwave devices employing Faraday rotation, electromagnetic resonators. Survey of semiconductor devices suitable for microwave frequencies.

EE 409 — Project Laboratory I — (0-4)2
[Permission of Instructor]

The purpose of this course is to provide an opportunity for

qualified electrical engineering seniors to investigate specific areas of interest. Interested students apply for specific projects as advertised by staff members. At the discretion of the staff, students are assigned as individuals or team members to the projects. The projects themselves are research and development oriented and usually involve a substantial amount of laboratory work. A practical attitude and environment is maintained for the duration of the project. Design reviews, progress reports, and a final report is expected for each project.

EE 410 Project Laboratory II (0-4)2

[Permission of Instructor]

The purpose of this course is to provide an opportunity for a student to either continue his investigation undertaken in EE 409 or to initiate a new project which is not related to his EE 409 work.

EE 411 Logic Design of Digital Systems I (3-0)3

[EE 328]

An extension and elaboration of the number system, Boolean algebraic, and combinatorial logic concepts introduced in EE 328. An introduction to threshold and majority logic. Minimization techniques including Boolean algebraic manipulation, the Karnaugh map method, and the Quine-McCluskey tabular method. Simplification techniques are also applied to multiple output circuits and incompletely specified functions. Additional topics include basic digital system building blocks such as the adder and shift register, error detection and correction codes, and an introduction to sequential machines.

EE 412 Logic Design of Digital Systems II (3-0)3

[EE 411]

The general characteristics of finite synchronous and asynchronous sequential machines. State diagrams, state tables, implication tables and graphs are used to determine equivalent states and therefore equivalent minimal sequential machines. State assignment and complete machine logic design. Hazards in combinational and sequential networks. Introduction to neural networks, Turing machines, and automata.

EE 413 Linear Feedback Systems (3-0)3

[EE 362]

Concept of feedback: open loop and closed loop systems. Feedback in electrical, mechanical, biological, economic and social systems. Mathematical models of systems and linear approximations. Transfer functions of linear systems, block diagrams and signal flow graphs. Sensitivity, control of transient response, disturbance signals. Time domain performance: steady state errors, performance indices. Stability related to s plane lo-

cation of the roots of the characteristic equation. Routh-Hurwitz criterion. Graphical analysis techniques: root locus, frequency response as polar plots and Bode diagrams. Closed loop frequency response and Nichols chart.

EE 414 Feedback Control Systems (3-0)3
[EE 413]

Time domain analysis of feedback control systems, compensation, Truxal's synthesis procedure, Chen's Method, complex control systems and ac carrier systems.

EE 416 Electronic Amplifier Circuits (3-0)3
[EE 366]

An integrated treatment of the analysis and design of electronic amplifiers. Topics such as noise, noise figure, intermodulation, intercept point, VSWR, and frequency response are covered. Emphasis is then placed on the choosing of electronic devices and circuit configurations based on amplifier and system design objectives.

EE 417 Absolute and Symbolic Programming (3-0)3
[EE 328]

An introduction to absolute and symbolic programming and coding fundamentals. Typical digital computer organization; breakdown of functional blocks including arithmetic unit, control unit, memory and input-output structure. Computer word formats; single and double precision, floating point and instruction words. Machine instructions and methods of execution. Symbolic coding. Address modification, index registers and looping. Subroutines, calling sequences and utility routines. Input-output programming. Table processing techniques. Programs will be run by students on the Electrical Engineering Department's HP 2116B computer.

EE 425 Wave Shaping and Generation I (3-0)3
[EE 366]

Principles and methods of wave shaping and wave generation using active and passive elements. Pulse transformers, delay lines, wideband amplifiers and steady-state switching characteristics of electronic devices. Clipping, comparator, clamping, and switching circuits. Logic circuits.

EE 426 Wave Shaping and Generation II (3-0)3
[EE 425]

Bistable, monostable and astable multivibrators. Negative resistance devices and switching circuits. Voltage and current time base generators. Blocking-oscillator circuits, sampling gates, counting and timing, synchchronization and frequency division.

EE 429 — Network Synthesis (3-0)3
[EE 362, MA 315]

Review of linear system analysis methods: consideration of natural frequencies for impedance-by-inspection techniques. Tellegen's theorem: general reciprocity relation and driving-point impedance characteristics. Positive-real functions: definitions and tests. Hurwitz polynomials and Sturm tests. Properties of LCT, RCT, RLT, and RLCT one-ports with Cauer, Foster, and Brune network realizations. Partial-pole removals and introduction to transfer function realizations.

EE 435 through EE 438 — Special Topics in Electrical Engineering (3-0)3

Study of undergraduate subjects related to electrical engineering not otherwise included in curriculum. Topics selected from recent developments in the field of electrical engineering.

EE 439 — Introduction to Electrical Systems (3-0)3
[EE 362, EE 366]

Introduction to the basic theory underlying geographically large electrical systems such as communication systems and power distribution networks. Principles of amplitude modulation and its application to frequency-division multiplex systems. Effects of higher-order modulation products. Frequency and phase modulation, Pulse-code modulation and other forms of pulse modulation including their use in time-division multiplex systems. Survey of radio propagation.

EE 440 — Electrical Communication System (3-0)3
[EE 439 or EE 463]

Advanced study of communication systems. Statistical properties of signals and noise. Power spectra and correlation. Thermal and shot noise. Noise figure and noise temperature. Detection of signals in noise. Introduction to information systems. Simple error-detecting codes and other theoretical problems in communication and radar systems.

EE 444 — Electrical Power Systems (3-0)3
[EE 202]

An intermediate course in analysis and operation of electrical power systems. Consideration will be given to fault studies in polyphase systems, load flow, economic dispatch and unit commitment, and system stability.

EE 445 Analog Devices and Techniques (3-0)3
[EE 366]

A survey of analog devices and techniques; particularly those involving the use of operational amplifiers. Primary emphasis is on general techniques although the design and programming of conventional analog computers are discussed extensively as examples of application of the techniques.

EE 446 Digital Devices and Techniques (3-0)3
[EE 328, EE 366]

A detailed study of basic digital devices and how these devices are combined into large digital systems. Emphasis is placed on the design aspects of digital systems and models of modern mini-computers are examined. Digital building blocks, such as registers, multiplexers, decoders, encoders, as well as larger digital sub-systems such as memories, arithmetic units, and digital controllers are studied.

EE 461 Electromagnetic Theory II (3-0)3
[EE 360]

Extension of EE 360 to time varying fields. Topics include: Faraday's law, displacement current, Maxwell's equations, plane waves, Poynting's theorem, skin depth, transmission line theory, Smith chart.

EE 463 Introductory Communication Theory (3-0)3
[EE 362]

This course, a continuation of EE 362, involves a study of mathematical methods in communication theory. Topics considered are: temporal waveform multiplication and frequency convolution applied to amplitude modulation. Hilbert transforms and SSB transmission. Introduction to angle modulation: Bessel functions, narrow and wideband FM. Sampling theorem and signal space and Z-transforms. Multiplexing in frequency and time domains. Pulse modulation: amplitude frequency, position and code (PCM). Signal comparison — correlation and energy spectral densities. Shot and thermal noise applied to linear systems and comparative analysis of communication systems with noise. Introduction to information theory.

EE 465 Direct Energy Conversion (3-0)3
[EE 355]

Review of first and second law of thermodynamics; thermoelectric, photoelectric, and thermionic conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion Fusion. Nuclear fission, reactor theory, reactor control and operation.

EE 471 Modern Energy Conversion Methods (3-0)3
[MA 232 or MA 234, PH 245]
[Not open to students majoring in Electrical Engineering]

Dc electromechanical energy conversion, synchronous converters, inductive energy conversion, transformers. Dynamic analysis using Lagrange's equations. Thermoelectric, thermionic and photoelectric energy conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion. This course is primarily intended to acquaint the nuclear engineer with the modern energy conversion methods available for use in conjunction with a nuclear reactor.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well qualified undergraduate students.

EE 503 Solid-State Physical Electronics I (3-0)3
[EE 360]

Introduction to the behavior of solid-state electronic devices from the viewpoint of modern physics: review of classical mechanics and Maxwell's equations. The Bohr atom, wave-particle duality, wave packets, Schroedinger's equation, band theory of solids, electrons and holes. Mechanical and acoustical properties of solids, semiconductor behavior.

EE 504 Solid-State Physical Electronics II (3-0)3
[EE 503]

Continuation of EE 503. Semiconductor devices: Schottky diodes, p-n junction devices, junction transistors, field-effect transistors, photo-diodes, varactors. Electro-optic devices, thermo-electric devices, electro-luminescent diodes and laser diodes. Magnetism and magnetic devices.

EE 505 Microwave Electronics I (3-0)3
[EE 461]

Electromagnetic theory, transmission lines, impedance matching, waveguides antennas, microwave oscillators and amplifiers, klytrons, magnetrons, traveling wave tubes, and solid state devices.

EE 507 Electromagnetics I (3-0)3
[EE 461]

Radiation from various types of antennas. Propagation of electromagnetic waves through bounded and unbounded media.

EE 508 Electromagnetics II (3-0)3
[EE 507]

Derivation of Maxwell's Equations from the postulates of

special relativity. The solution of boundary value problems through the use of Green's Functions, special functions, and the Schwarz-Christoffel transformation.

EE 509 Linear Systems Analysis (3-0)3
[EE 362]

Classical solution of linear systems described by differential equations. Duals, analogs, and electromechanical systems. System function, step and impulse response, and initial conditions. Time-domain convolution. Fourier analysis, series, and integral: impulse method for obtaining transforms. Laplace transforms: evaluation and properties. Complex variable theory: complex differentiation and Cauchy-Riemann equations. Complex integration: Cauchy's theorem and Cauchy's integral formulas. Taylor and Laurent series and the residue theorem. Inverse Laplace transforms. Introduction to Z-transforms.

EE 515 Nonlinear Control Systems (3-0)3
[EE 413]

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function, the methods of Lyapunov and Popov and other nonlinear analysis techniques are treated.

EE 517 Optimal Control Systems (3-0)3
[EE 413]

A study of the analysis and design of optimal control systems by dynamic programming, calculus of variations, and Pontryagin's Method.

EE 519 Discrete Data Control Systems (3-0)3
[EE 413]

The sampling process, reconstruction of sampled signals, transforms, inverse Z-transforms and flow graph representation of digital systems. The state variable approach to discrete data systems, time solutions by state variable methods. Stability of discrete data systems. Introduction to optimal control of discrete data systems.

EE 521 Automata Studies (3-0)3
[EE 412]

Mathematical foundation of automata, including probabilistic logics, neuron analogs, Turing machines, and learning theory.

EE 523 Digital Computer Software (3-0)3
[EE 563]

Examination of computer system software as an information processing function. Description of information structures. Formal languages, their syntax and semantics. Text processing pro-

grams and text editors. Assembly language and processing. Real-time system softwave. Time sharing and program sharing techniques in real-time systems.

EE 525 Simulation Techniques (3-0)3
[EE 328, EE 445]

A study of modern analog, digital and hybrid techniques for the simulation of continuous and discrete systems and processes. The student is expected to study a number of practical engineering systems through the use of simulation techniques on available analog, hybrid and digital computers.

EE 529 Network Synthesis I (3-0)3
[EE 362]

A review of natural frequencies and analysis techniques; complex variable topics such as conformal mapping, maximum modulus theorem, and Laurent series. Tellegen's theorem. Positive real (p.r.) functions developed from four different viewpoints, including reflection coefficients. Methods for testing p.r. functions; Hurwitz test, Sturm test, and residue tests. Quadratic forms and the testing for p.r. matrices. Properties of the driving-point and transfer immittances of LCT RCT, and RLT networks, Cauer and Foster network realizations, partial pole removals. Cauer transformations. RLCT Brune realizations.

EE 530 Network Synthesis II (3-0)3
[EE 529]

RLCT driving-point synthesis methods of Darlington, Bott-Duffin, Miyata and Fialkow-Gerst. Transfer synthesis methods of Darlington, constant-resistance lattice, RC ladder. Approximation problems using Butterworth functions, dissipation and predistortion techniques. An introduction to active network synthesis.

EE 537 Introduction to Bio-Medical Engineering (3-0)3
[EE 366]

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed.

EE 539 Biological Systems (3-0)3
[EE 413, EE 445, EE 537]

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required.

EE 545 Coding Theory (3-0)3
[MA 533]

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail.

EE 547 Statistical Communication Theory (3-0)3
[MA 584]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 584]

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

EE 549 Introduction to Lasers and Masers (3-0)3
[EE 362, EE 461 or equiv.]

A first course on Lasers and Masers and their applications. Classical electromagnetic theory as well as introductory Quantum Mechanics serve to provide the proper background to engineering students interested in industrial and scientific laser applications. Typical topics include interferometry, liquid crystals and fiber optics, harmonic generation, and holography.

EE 551 Electro-Optics (3-0)3
[EE 362, EE 461,]

Principles of optical propagation as described by the Fresnel-Kirchhoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 561 Computer Organization and Design (3-0)3
[EE 411, EE 417]

A critical examination of the organization of present day digital computers from both the software and hardware points of view. Computer design with hardware-software trade-off. Comparison of instruction sets, their hardware implementation. Examination of the input-output structures of selected examples. Multi-processing and parallel processing. Detailed examination of a large system and of several mini-computers. Students are

expected to simulate certain aspects of the example computers on available digital computers.

EE 563 System Programming (3-0)3
[EE 417]

The definition of system programming as programming in a multi-user environment. Programming with and for interrupts. Reentrant programming, pure procedures. Communication between program modules. Nested calls, the push-down stack. Recursive program calls. Reentrant interrupt programming. Activation records and program sharing. Character and list handling routines. Input-output systems. Representative programs of the above topics will be programmed by the student in assembly language on the HP 2116B computer.

EE 571 Introduction to Radar Systems (3-0)3
[EE 439]

Introduction to both pulsed and C.W. radar systems. Detection of radar echoes in noise. The radar equation and its use in estimating performance of a radar system. Estimation of range, direction and velocity of targets. Moving target indicators (MTI). Pulse compression and other advanced techniques. Discussion of elements of practical radar systems.

EE 574 Digital Subsystem Design I (3-0)3
[EE 417, EE 446]

The definition of a particular digital subsystem in terms of a nested set of smaller subsystems, each performing a subset function such as data formating, data buffering, data storage, synchronization, switching, and specialized algorithms. The relationship of the overall system to its environment is used to develop solution algorithms at the register transfer level. Simulation of these RTL designs using SIM16 and an evaluation of the cost, performance and adaptability of each algorithm in both its hardware and software versions is performed as an aid to the designer in selecting the most feasible scheme for use in the detailed subsystem realization.

EE 575 Digital Subsystem Design II (3-0)3
[EE 574]

An overview of the design process developed in EE 574 with emphasis on developing algorithms at the subsystem and subset function levels, decomposition of these algorithms into detailed RTL flowcharts showing registers, transfer paths, control and timing paths. The flowchart is converted to a detailed wiring diagram for each hardware algorithm with factors such as speed, fan-in and fan-out, and the availability of complex logic functions controlled by the logic family selected. Digital subsystem projects include the design, bread-boarding and testing of peripheral interfaces or special application subsystems.

EE 577 State Variable Analysis of Systems (3-0)3

[EE 362]

Algebra of matrices, vector spaces and linear transformations. Calculus of matrices, matrix functions and the solution of differential and difference equations as formulated by the state variable characterization of systems. A consideration of canonical forms for computer simulation.

EE 581 Electrodynamics (3-0)3

[EE 355]

The main focus of this course is the transient analysis of electromechanical devices, including electromechanical transducers and ac and dc machines. Topics covered include stored electric and magnetic energy, electric and magnetic forces, dynamic models of electromechanical devices, solution of differential equations to obtain equations of motion, driving point impedances, transfer functions for linear devices, and methods of approximation for nonlinear devices. Applications covered include magnetic transducers, piezo-electric transducers, transient analysis of power systems, and the formulation of mathematical models of servomechanism components.

EE 901 Introduction to Industrial Electricity (3-0)3

[For Engineering Technology students only]

An introduction to elementary circuit analysis. The course content includes the study of transformers, rotating machines, vacuum tubes, transistors, integrated circuits, analog and digital devices.

EE 902 Industrial Electricity Laboratory (1-3)2

[For Engineering Technology students only]

A laboratory experience verifying the concepts of EE 901 and an exposure to the measurement of various electrical and mechanical parameters.

EE 975 Basic Electricity (3-3)4

[PH 942, 45.41]

[For Engineering Technology students only; see Division of Evening Studies Catalog]

An introduction to electric circuits for students who have a background in basic principles of electricity and magnetism. Includes illustrative laboratory projects.

EE 978 Basic Electronics (3-0)3

[EE 975]

[For Engineering Technology students only]

A background subject in electronics presenting the properties and applications of vacuum tube and semiconductor devices. Intended for the student who will use rather than design electronic circuits.

INDUSTRIAL TECHNOLOGY

The Industrial Technology program has been designed to increase the variety of educational opportunities available to undergraduate students at L.T.I. The program's objective is to prepare students for professional careers in the rapidly expanding fields of production, manufacturing and institutional systems. Their careers will encompass a broad band of activities touching on the one extreme, the engineering sciences and on the other, business administration.

The Industrial Technology Graduate, drawing on both his theoretical knowledge and his basic industrial skills, will be in a position to direct operations involved in the manufacture of finished products and components, to establish and supervise production procedures, to supervise the flow of supplies and products, and in general to cope with technical and managerial aspects of modern industry and institutions.

A significant feature of this new program is the possibility to incorporate - for academic credit - supervised industrial experience. This, together with the theoretical and applied background provided by the Institute, will make the graduate of this program flexible and capable of adapting to a wide variety of industrial organizations and problems.

The curriculum is a carefully organized interdisciplinary program providing a well-balanced education. Approximately 40% of the curriculum pertains to technical subjects such as measurements, numerical and automatic controls, manufacturing processes and operations; 20% of the curriculum consists of business subjects; another 20% relates to the social sciences and humanities. The balance lies in the mathematics and science areas. Sufficient electives are provided to permit students to fully round out their primary interest or pursue their career goals.

Because the students in Industrial Technology aspire to a large variety of professional goals, a flexible transfer credit policy is maintained. A student without transfer credit or advanced standing will take an average of 15 credits per semester. A total of 121 credits is necessary for graduation.

INDUSTRIAL TECHNOLOGY PROGRAM

FRESHMAN YEAR

First Semester

LL	111	English	(3-0)3
MA	101	College Algebra	(3-0)3
ME	271	Machine Tool Lab.	(1-3)2
PH	149	General Physics	(3-0)3
FS	001	Freshman Seminar	(1-0)_
PE	101	Physical Education	(0-2)1
		Humanistic-Social Elective	(3-0)3
		Total Hours	(14-5)15

Second Semester

CH	149	General Chemistry	(3-0)3
LL	112	English	(3-0)3
MA	102	Calculus	(3-0)3
ME	205	Intro to Eng. Design	(2-3)3
PE	102	Physical Education	(0-2)1
		Humanistic-Social Elective	(3-0)3
		Total Hours	(14-5)16

SOPHOMORE YEAR

First Semester

BA	143	Accounting Management I	(3-0)3
EC	201	Economics I	(3-0)3
IT	201	Structure of Metals	(2-3)3
MA	201	Math Analysis	(3-0)3
		Humanistic-Social Elective	(3-0)3
		Total Hours	(14-3)15

Second Semester

BA	144	Accounting Management II	(3-0)3
EC	202	Economics II	(3-0)3
EE	901	Industrial Electronics	(3-0)3
IT	202	Industrial Computer Science	(3-0)3
PL	211	Plastics	(2-2)3
		Total Hours	(14-2)15

JUNIOR YEAR

First Semester

BA	371	Production Principles	(3-0)3
EE	902	Industrial Power Circuits	(1-3)2
IT	301	Ceramics & Composites	(3-2)4
IT	303	Mechanical Power Transmission	(2-2)3
IT	305	Manufacturing Processes	(2-3)3
		Total Hours	(11-10)15

Second Semester

BA	372	Production Management	(3-0)3
IT	302	Instrumentation and Measurement	(2-2)3
IT	304	Tool & Fixture Design	(1-4)3
MA	383	Statistics	(3-0)3
SS	303	Psychology	(3-0)3
		Total Hours	(12-6)15

SENIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
LL	209	Technical Communications	(3-0)3
IM	484	Statistical Quality Control	(3-0)3
IT	401	Industrial Environmental Control	(3-0)3
		Free Elective*	(3-0)3
		Total Hours	(15-0)15

*ROTC Students may elect AS 401

Second Semester

BA	452	Industrial Relations	(3-0)3
EC	414	Engineering Economy	(3-0)3
IT	402	Manufacturing Operations	(3-0)3
IT	404	Industrial Automatic Controls	(2-2)3
		Free Elective*	(3-0)3
		Total Hours	(14-2)15

*ROTC Students may elect AS 402

INDUSTRIAL TECHNOLOGY COURSE DESCRIPTIONS

IT 201 Structure of Metals (2-3)3

A practical study of the structure of metals and the methods used to improve their properties for industrial applications. This course includes selection, heat treatment and fabrication of metals as well as their preparation and applications for use under extreme environmental conditions.

IT 202 Industrial Computer Science (3-0)3

A course to familiarize students with two different types of programming methods: FORTRAN for use with technical problems and COBOL for problems which arise in business and management fields. Students are required to execute a number of programs on the Institute computer.

IT 301 Ceramics & Composites (3-2)4

[IT 201 or PL 211]

This course is a continuation of the study of materials. It covers the third general classification of engineering materials, ceramics, and the structural potpouri of all engineering materials, composites. The study of ceramics will stress the way structure controls a material's ultimate properties and how these properties enter into the selection of ceramic materials for industrial applications. The study of composites will serve as a review of all materials and their interactions upon being combined into one material.

IT 302 Instrumentation and Measurement (2-2)3

[EE 902]

A course to familiarize students with instruments used in process control and product measurement. Topics include time constants; measurement of temperature, flow, pressure and level; precision measurement; gaging; testing for hardness, surface finish, profile and location. Laboratory exercises are coordinated with the classroom topics.

IT 303 Mechanical Power Transmissions (2-2)3

[Primarily for I.T. Students]

An introduction to the design or selection of mechanical elements used in the transmission of power in industrial machines. Topics include shafts, pulleys, gear trains, bearings, clutches and brakes.

IT 304 Tool and Fixture Design (1-4)3

[ME 205 or equivalent]

This course introduces students to the field of specialized production tools, jigs, gages and fixtures. The theory dimension-

al control as related to production machining is presented. A major portion of the course involves the layout and design of jigs and fixtures and the selection of the proper standard parts for these fixtures.

IT 305 Manufacturing Processes (2-3)3
[ME 271 or equivalent]

Students participating in this course will gain both a theoretical and a practical understanding of the principal manufacturing processes: casting, forming, chip removal, fastening methods, finishing processes, conditioning, and assembly techniques. Product design as related to manufacturing will be considered.

Laboratory experiences will include experiments with numerical control as well as field trips to various manufacturing concerns.

IT 401 Industrial Environmental Control (3-0)3

In this course students become familiar with the theory and techniques used to control the environment within enclosed spaces. Variables considered are heat, work energy, thermodynamics, fluid flow and heat transfer. Each student is required to undertake a class project encompassing the topics covered in the course.

It 402 Manufacturing Operations (3-0)3
[Senior Standing]

A senior level course dealing with plant layout, materials handling, product evaluation, set up and maintenance procedures, environmental controls, data processing in manufacturing and equipment selection.

IT 404 Industrial Automatic Controls (2-2)3
[EE 902, Senior Standing]

Applications of automatic control theory to industrial processes. Electronic, mechanical, hydraulic, pneumatic and fluidic control systems are selected and applied to specific problems. Digital logic; computer control, feedback loops; and critical settings on controllers. Laboratory work in the design, assembly and testing of commercial control systems.

MECHANICAL ENGINEERING

Mechanical engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production.and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and automatic controls (electricity, electronics, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, technical electives are provided. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

MECHANICAL ENGINEERING PROGRAM

FRESHMAN YEAR

First Semester

CH	121*	Chemistry	(3-0)3
CH	123	Chemistry Lab	(0-3)1
LL	111	English	(3-0)3
MA	131		
or			
MA	133	Col. Math I or Calculus I	(4-0)4
PH	141*	Physics	(3-1)3
FS	001	Fresh Seminar	(1-0)_
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted.

Second Semester

CH	122*	Chemistry	(3-0)3
CH	124	Chemistry Lab	(0-3)1
LL	112	English	(3-0)3
MA	132		
or			
MA	134	Col. Math II or Calculus II	(4-0)4
PH	144*	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	231		(4-0)4
or			or
MA	233	Col. Math III or Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
ME	271	Machine Tool Laboratory	(1-3)2
ME	211	Mechanics I	(3-0)3
PH	245*	Physics	(4-1)4
		Total Hours	(17-4)18 or 17

*PH 247 Honors Physics may be substituted.

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	232		(4-0)4
or			or
MA	234	Col. Math IV or Calculus IV	(3-0)3
ME	205	Intro. to Mechanical Design	(2-3)3
ME	206	Mechanical Engineering Lab. I	(0-3)1
ME	220	Mechanics of Materials I	(3-0)3
ME	242	Thermodynamics	(3-0)3
		Total Hours	(17-4)18 or (16-4)17

JUNIOR YEAR
First Semester

EC	201	Economics I	(3-0)3
MA	301	Advanced Calculus for Applications	(3-0)3
ME	307	Mechanical Engineering Laboratory II	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
ME	395	Materials Science	(3-0)3
		Total Hours	(15-3)16

Second Semester

EC	202	Economics II	(3-0)3
ME	308	Mech. Eng. Lab III	(0-3)1
ME	320	Machine Design I	(2-3)3
ME	343	Heat Transfer	(3-0)3
ME	354	Dynamics Systems	(3-0)3
		Humanistic-Social Elective	3
		Total Hours	16

SENIOR YEAR
First Semester

ME	407	Mechanical Engineering Laboratory IV	(0-3)1
ME	453	Senior Project I	(0-3)1
ME	497	Automatic Control Systems	(3-0)3
		Humanistic-Social Elective*	3
		Humanistic-Social Elective	3
		Technical Elective	3
		Free Elective	3
		Total credit hours	17

ROTC students may elect AS 401

Second Semester

ME	413	Gas Dynamics or	(3-0)3
ME	474	Thermodynamic Applications	
ME	454	Senior Project II	(0-6)2
		Technical Elective	3
		Technical Elective	3
		Humanistic-Social Elective*	3
		Free Elective	3
		Total credit hours	17

ROTC students may elect AS 402

APPROVED TECHNICAL ELECTIVES

EC	414	Engineering Economy	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
MA	362	Numerical Analysis	(3-0)3
MA	452	Application of Numerical Analysis	(3-0)3
ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	422	Machine Design II	(2-3)3
ME	428	Kinematic Mechanism Synthesis	(3-0)3
ME	462	Engineering Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	473	Mechanics of Materials II	(3-0)3
ME	475	Physical Metallurgy	(3-0)3
ME	477	Composite Materials	(3-0)3
ME	480	Advanced Projects in Systems and Design	(1-6)3
ME	483	Aerodynamics	(3-0)3
ME	488	Environmental Conditioning	(3-0)3
ME	500	Series subjects open to undergraduates by Department Approval.	

Other subjects may be taken as Technical Electives with the approval of the Advisor.

MECHANICAL ENGINEERING COURSE DESCRIPTIONS

ME 201 — Graphics — (1-0)1

The technique of communicating engineering information and concepts by means of orthographic drawings, pictorial views and sketches. Charts, graphs, graphical calculus, fundamentals of descriptive geometry.

ME 205 — Introduction to Engineering Design — (2-3)3

[ME 271]

The process of mechanical design, with emphasis on graphical communication and layout. Lectures on design, drawing, dimensioning, fasteners, gears, cams, bearings and manufacturing techniques. Laboratory experiences in sketching, layout and design drawing. Demonstrations of machine tool operations including numerical control. Students must complete a comprehensive design project.

ME 206 — Mechanical Engineering Laboratory I — (3-0)1

[ME 220, ME 242 Concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in mechanics of materials and thermodynamics.

ME 211 — Mechanics I — (3-0)3

[MA 132 or MA 134; PH 141]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situa-

tions. The concept of stress and strain at a point. The stress-strain-temperature relations. Virtual Work.

ME 212 Introductory Mechanics (4-0)4
[MA 232 or MA 234; PH 144]

Study of deformable solids, respond to mechanical loading, stress, strain, and elastic moduli for various materials. The study of dynamics and kinematics, Newton's second law including momentum and energy forms. Applications include rigid body motion, colliding particles, vibrating systems and electrical analogues, and central force systems.

ME 215 Analytic Mechanics I (3-0)3
[MA 132 or MA 134; PH 141]
[Primarily for CN, and PL students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Analytic Mechanics II (3-0)3
[ME 215]
[Primarily for CN, and PL students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 Mechanics of Materials I (3-0)3
[MA 231 or MA 233; ME 211]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 242 Thermodynamics (3-0)3
[MA 231 or MA 233; PH 144]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability. Energy Conversion cycles.

ME 271 Machine Tool Laboratory (1-3)2

Lectures, demonstrations and laboratory experience in material processing. The student becomes familiar with the purpose and operation of industrial machine tools for turning, grinding, mill, shaping, and electrical discharge machining. Design and programming for numerical control, foundry practice, die-casting, welding.

ME 307 Mechanical Engineering Laboratory II (0-3)1
[ME 309, ME 382, ME 395, all concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, fluid mechanics and materials science.

ME 308 Mechanical Engineering Laboratory III (0-3)1
[ME 343, ME 354, both concurrently]

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics systems and heat transfer.

ME 309 Dynamics I (3-0)3
[MA 232 or MA 234; ME 211, PH 144]

Vector development of kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. Energy, impulse and momentum.

ME 315 Applied Mechanics (3-0)3
[MA 132 or MA 134; PH 141]
[Primarily for IM students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 Machine Design I (2-3)3
[ME 220]

The principles of mechanics and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 343 Heat Transfer (3-0)3
[ME 242 or ME 347; ME 382 concurrently]

Theory and application of steady and transient heat conduction in solids. Mathematical development of hydrodynamic and thermal boundary layer theory. Forced convection, natural convection, heat exchangers. Development of thermal radiation with application to heat exchange between non-black bodies.

ME 344 **Heat and Power** **(3-0)3**

[MA 132 or MA 134]

[Primarily for IM students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 347 **Elements of Thermodynamics and Heat Transfer** **(3-0)3**

[MA 231 or MA 233; PH 144]

[Primarily for CE and EE students]

A study of the first and second law of thermodynamics with application to system and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases.

ME 354 **Dynamic Systems** **(3-0)3**

[MA 301, ME 309]

Unified approach to the modeling of simple mechanical, electrical, thermal and fluid systems. Transient and steady-state response of first and second order systems via classical and Laplace transform techniques. Supporting laboratory exercises emphasize real system behavior and associated physical measurement problems; error analysis.

ME 372 **Strength of Materials** **(3-0)3**

[ME 315]

[Primarily for IM students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 373 **Mold and Die Design** **(2-3)3**

[Primarily for PL and IT students]

The fundamentals and basic principles of mold and die design for injection, compression, transfer, thermoforming and extrusion processes. Design considerations will include metal selection, runner and gate construction for the various polymeric materials. Laboratory will consist of actual design of a mold or die, with emphasis on relative drafting.

ME 376 **Mold Design and Construction** **(0-3)1**

[ME 271, ME 373]

[Primarily for PL and IT students]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the machines in the Department of Plastics Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 Fluid Mechanics I (3-0)3
[ME 211; MA 301 concurrently]

Development of basic fluid mechanical relations; continuity, momentum, and Bernoulli equations. Emphasis on control volume approach to problem solving. Hydrostatics. Boundary layer concept, separation, Reynolds number, fluid dynamic drag. Angular momentum principles with application to turbomachinery.

ME 395 Materials Science (3-0)3
[CH 122, PH 144]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 407 Mechanical Engineering Laboratory IV (0-3)1
[ME 497; ME 413 or ME 474 concurrently]

A series of laboratory experiments which supplement the simultaneous activities in gas dynamics, thermodynamics and automatic controls.

ME 413 Gas Dynamics (3-0)3
[ME 242, ME 382]

Extension of basic fluid mechanical equations of motion to inviscid, compressible flows. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Prandtl-Meyer expansion.

ME 417 Dynamics II (3-0)3
[ME 354]

Generalized coordinates and Lagranges' Equations. Solutions to both linear and nonlinear one degree-of-freedom mechanical systems. Phase plane techniques and multi-degree-of-freedom systems.

ME 419 Nondestructive Evaluation Techniques (3-0)3
[Senior Standing]

The nondestructive evaluation of materials and processes by

penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical and metallurgical properties.

ME 422 Machine Design II (2-3)3
[ME 320]

A continuation of ME 320. Laboratory problems emphasize aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria.

ME 424 Case Studies in Design (1-3)2
[ME 320]

Case studies of design problems from the case study library are investigated by the entire class. Smaller groups are then formed to study current industrial design problems. Reports on the studies are presented to the class.

ME 428 Kinematic Mechanism Synthesis (3-0)3

Methods of designing mechanisms to convert given input motions to required output motions. Topics include function generation, coupler curves, position coordination, and spatial mechanisms. Problems are designed for solution by graphical methods, by computer solution using the analog and digital computers.

ME 453 Senior Project I (0-3)1
[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members. The first term is devoted to problem definition, solution synthesis and design analysis.

ME 454 Senior Projects II (0-6)2
[ME 453]

A continuation of ME 453. The second term is devoted to trade off and optimization, contruction, testing, evaluation and reporting.

ME 462 Engineering Analysis (3-0)3
[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Categories of successful engineering models, and the techniques for applying these models to contemporary problems of an interdisciplinary nature.

ME 468 **Fluid Machinery** **(3-0)3**
[ME 242, ME 382]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-dimensional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation.

ME 472 **Experimental Stress Analysis** **(2-3)3**
[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distribution by experimental methods. Photoelasticity, birefringent coatings, brittle coatings, analogies, strain gage applications, rosette analysis.

ME 473 **Mechanics of Materials II** **(3-0)3**
[MA 301, ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center, unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections.

ME 474 **Thermodynamics Applications** **(3-0)3**
[ME 242]

Application of basic laws of thermodynamics to power and refrigeration cycles. Mixtures of ideal gases, and air-water vapor mixtures with application to air conditioning. Combustion. Flow of a compressible fluid through a nozzle. Mach number, choking, normal shock.

ME 475 **Physical Metallurgy** **(3-0)3**
[ME 395]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phonomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture.

ME 477 **Composite Materials** **(3-0)3**
[ME 220, ME 395]

The course devotes attention to various types of composite materials used in modern industries. Both particulate and fiber reinforced materials are studied from fabrication, application, analysis and design view-points.

ME 480 **Advanced Projects in Systems and Design** **(1-6)3**
[Senior Standing]

For the student desiring to carry on substantial projects of his own choosing in the areas of engineering design, svstems or

automatic controls. Special lectures and seminars to be arranged when appropriate. Projects arranged on an individual basis in consultation with instructor.

ME 483 — Aerodynamics — (3-0)3
[ME 382]

Fundamentals of subsonic aerodynamics. Atmosphere models. Airfoil data, and lift and drag of aircraft components. Three dimensional wing theory and aspect ratio corrections. Aircraft performance, with an introduction to jet propulsion.

ME 488 — Environmental Conditioning — (3-0)3
[ME 242 or ME 347]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces.

ME 497 — Automatic Control Systems — (3-0)3
[ME 354]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 530 — Ultrasound, A Nondestructive Evaluation Method — (2-3)3
[ME 395]

Propagation characteristics of ultrasound are developed and analyzed to indicate usefulness as a nondestructive method of evaluation. Equipment for generation detection and display. Scientific and engineering applications using velocity and attenuation measurements are stressed.

ME 531 — Advanced Thermodynamics — (3-0)3
[ME 242, MA 301]

A comprehensive treatment of the classical first and second law. Availability, criteria of equilibrium, heterogenous systems, mixtures and solutions, chemical equilibrium. Introduction to statistical methods as applied to evaluation of thermodynamic properties.

ME 534 — Transport Processes — (3-0)3
[ME 343]

Diffusive and convective transport of mass, momentum and energy. Free and forced convection in laminar and turbulent flows. High velocity flows, ablation, boiling and condensation.

ME 535 **Advanced Heat Transfer** **(3-0)3**

[ME 343]

Heat conduction: analytical and numerical solutions. Thermal stresses. Laws of thermal radiations. Combined modes of heat transfer. Heat transfer in the environment and in biological systems. Thermal pollution.

ME 541 **Advanced Fluid Mechanics** **(3-0)3**

[ME 382]

Basic equations of incompressible flow. Flow in open channels. Water waves. Flow over airfoil; lift and drag. Creeping flow and theory of lubrication. Boundary layer. Introduction to the statistical theory of turbulence. Experimental techniques.

ME 542 **Advanced Gas Dynamics** **(3-0)3**

[ME 382, ME 382]

Equations of motion for inviscid, compressible fluid. One-dimensional steady flow with area change, friction, heat transfer and combustion. Shock waves. Unsteady flows and wave phenomena. Similarity, characteristics, small disturbances, approximation procedures.

ME 544 **Acoustics** **(3-0)3**

Fundamentals of the propagation of sound in fluids, solids and structures. Included will be a development of the basic concepts and equations and the application of these to special topics such as physiology, underwater acoustics, and sound control.

ME 546 **Energy Conversion** **(3-0)3**

[EE 212, MA 302, ME 343]

Concepts of thermodynamics pertaining to energy conversion, irreversible thermodynamics. Solid-state phenomena involved in conversion processes; energy forms, equations of states and energy fields. Selected topics in direct energy conversion systems.

ME 552 **Continuum Mechanics** **(3-0)3**

[ME 220, ME 242, ME 382]

Stress and deformation in a continuum in tensor notation. Fundamental laws of mechanics and thermodynamics. Applications to elastic, viscous and viscoelastic substances.

ME 554 **Theory of Elasticity** **(3-0)3**

[ME 473, ME 551]

Formulation of the problem of elastic equilibrium. Torsion and flexure of prismatic bars, contact stresses, plane stress, plain strain and stress concentrations.

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ME 556 **Theory of Inelastic Continuum** **(3-0)3**

[ME 473, ME 551]

Development of the constitutive equations governing inelastic (anelastic, viscoelastic, plastic and visco-plastic) deformations. Theorems and boundary valve problems as applied to inelastic continua.

ME 558 **Plates and Shells** **(3-0)3**

Variational methods are utilized to derive the plate and shell equilibrium equations including nonlinear effects and inertia terms. Solutions to bending, buckling, and vibration problems are obtained for rectangular and circular plates. The membrane theory of shells as well as the general theory is investigated and solutions are obtained for a variety of practical shell problems.

ME 562 **Advanced Dynamics** **(3-0)3**

[ME 417]

Dynamics of mechanical systems by use of direct and variational methods. Three-dimensional rigid body dynamics, and vibrations of lumped parameter and continuous systems. Nonlinear and self-excited oscillations. Stability.

ME 564 **Structural Dynamics** **(3-0)3**

[ME 417]

Response of complex structures to deterministic and random excitations. Exact and approximate normal modes by energy, and by differential and integral methods. Proportional and nonproportional damping.

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry, strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics and quality control augment the basic courses in mathematics, sciences and engineering to round out a well-balanced program in Plastics Technology.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the international Society of Plastics Engineers, an opportunity which affords every student member an early and rewarding professional association.

PLASTICS TECHNOLOGY PROGRAM

FRESHMAN YEAR

First Semester

CH*	121	Chemistry	(3-0)3
CH	123	Chemistry Lab.	(0-3)1
LL	111	English	(3-0)3
MA	131	College Math. I.	(4-0)4
or			
MA	133	Calculus I	(4-0)4
PH	141*	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)_
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

CH	126*	Chemistry	(3-0)3
CH	124	Chemistry Lab.	(0-3)1
LL	112	English	(3-0)3
MA	132	College Math. II	(4-0)4
or			
MA	134	Calculus II	(4-0)4
PH	142*	Physics	(3-1)3
PE	102	Physical Education	(0-2)1
		Total Hours	(13-6)15

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOHPOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry I	(3-0)3
CH	225	Introductory Organic Chemistry Lab. I	(0-4)1
MA	231	College Mathematics III	(4-0)4
or			
MA	233	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
PH	243*	Physics	(3-1)3
PL	201	Polymeric Materials I	(2-2)3
		Total credit hours	16 or 17

*PH 247 Honors Physics may be substituted

Second Semester

CH	224	Introductory Organic Chemistry II	(3-0)3
Ch	226	Introductory Organic Chemistry Lab. II	(0-4)1
ME	216	Analytic Mechanics II	(3-0)3
PL	202	Polymeric Materials II	(2-2)3
PL	204	Process Control Systems	(3-0)3
		Humanistic — Social Elective	3
		Total credit hours	16

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-0)3
CH	337	Principles of Physical Chemistry Lab.	(0-3)1
EC	201	Economics I	(3-0)3
PL	301	Polymeric Materials III	(2-2)3
PL	373	Plastics Mold Engineering I	(2-2)3
		Technical Elective	3
		Total credit hours	16

Second Semester

CH	336	Principles of Physical Chemistry	(3-0)3
CH	338	Principles of Physical Chemistry Lab.	(0-3)1
EC	202	Economics II	(3-0)3
PL	302	Polymeric Materials IV	(2-2)3
		Humanistic — Social Elective	3
		Technical Elective	3
		Total credit hours	16

SENIOR YEAR

First Semester

CH	403	Introductory Physical Chemistry of Macromolecules	(3-0)3
CH	405	Polymer Laboratory I	(0-4)1
PL	401	Plastics Technology	(3-0)3
PL	403	Physical Properties of Polymers	(2-2)3
PL	405	Methods of Polymer Characterization	(2-0)2
PL	411	Plastics Seminar	(1-0)1
		Humanistic — Social Elective*	3
		Total credit hours	16

*ROTC students may elect AS 401

Second Semester

CH	404	Introductory Organic Chemistry of Macromolecules	(3-0)3
CH	406	Polymer Laboratory II	(0-4)1
PL	402	Plastics Technology	(3-0)3
PL	404	Physical Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
		Humanistic — Social Elective*	3
		Free Elective	3
		Total credit hours	17

*ROTC students may elect AS 402

Recommended Technical Elective

LL	210	Technical and Scientific Communication	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
ME	395	Material Science	(3-0)3
PL	376	Plastics Mold Engineering II	(2-2)3
PL	406	Polymer Structure, Properties, and Applications	(3-0)3
PL	413	Senior Projects I	(0-2)1
PL	414	Senior Projects II	(0-2)1
PL	507	Plastics Industry Organization	(3-0)3

PLASTICS TECHNOLOGY

COURSE DESCRIPTIONS

PL 201 — Polymeric Materials I — (2-2)3

A descriptive subject to acquaint the student with plastics as a class of materials. The history, classification, definition, raw materials, methods of manufacture, properties and uses of polymeric materials. Introduction to laboratory methods in the processing and fabrication of plastics materials.

PL 202 — Polymeric Materials II — (2-2)3

[PL 201 or Permission of Instructor]

A continuation of PL 201. Emphasis is placed on the engineering thermoplastics. Polymers for thermal extremes as well as many of the newer high performance plastics are also discussed. Introductory laboratory instruction is continued.

PL 204 — Process Control Systems — (3-0)3

[PH 142 or PH 148 or Permission of Instructor]

Basic principles of control systems used with plastics processing equipment. Included are hydraulic, pneumatic, electromechanical, pressure and temperature control devices.

PL 211 — Plastics Material Science — (2-2)3

[Primarily for Industrial Technology majors]

Discussion of the historical development of polymeric materials, related classification systems, and methods of manufacture. Survey of the more prominent resin families with particular emphasis on the engineering plastics. Review of end-use applications with respect to pricing, processing, and performance.

PL 301 — Polymeric Materials III — (2-2)3

[PL 201, PL 202 or Permission of Instructor]

Analysis of additives including stabilizers, plasticizers, biocides, release agents, flame retardants, colarants and foaming agents as well as modifiers, fillers and reinforcing agents. Laboratory instruction of a more advanced nature in the processing and fabrication of plastics molding materials is introduced.

PL 302 — Polymeric Materials IV — (2-2)3

[PL 301 or Permission of Instructor]

Discussion of compounding techniques and the evaluation and development of typical plastics molding compounds. Survey of materials for reinforced plastics and composites, film and sheeting, adhesives, and non-plastics applications of polymers.

PL 371 — Introduction to Plastics Mold and Die Design Principles — (2-2)3

[Primarily for Industrial Technology Majors]

Course work entails primary exploration of the fundamental principles of mold and die design. Emphasis is placed in an intradisciplinary approach to mold design to include the interrelationships of materials processing, product design, mold and die design/construction, and design communications. Laboratory consists of case study approach to the lecture material, and the design of simple molds.

PL 373 — Plastics Mold Engineering I — (2-2)3

Course work entails the introduction to the fundamentals of plastics mold and die engineering with the objective to develop an overall appreciation of the mold engineer's job. Emphasis is placed on an intradisciplinary approach to mold engineering to include the interrelationships of polymeric materials processing, plastics product design, mold and die design/construction, and design communications. Laboratory consists of the actual design of a mold or mold components with emphasis on mechanical drawing in design communications.

PL 376 — Plastics Mold Engineering II — (2-2)3

[PL 373]

Course work entails indepth exploration of the fundamental principles of plastics mold and die engineering to include cavity design, material feed "systems", rheology and orientation within the mold, ejection systems, parting surfaces, mold "action", and thermodynamic considerations. Emphasis is placed on injection and "prototype" mold design. Laboratory consists of case study approach to the lecture material, and the design and construction of prototype molds.

PL 401 — Plastics Technology — (3-0)3

A theoretical and practical study of plastics process engineering. Correlation of composition, processing and fabrication with mold, product and equipment design.

PL 402 — Plastics Technology — (3-0)3

A continuation of PL 401

PL 403 — Physical Properties of Polymers — (2-2)3

[Open to seniors only]

Introduction to basic mechanical properties of polymers as linear viscoelastic materials. Concepts of creep, stress relaxation, and superposition principles emphasized. Important material parameters are obtained in laboratory sessions.

PL 404 Physical Properties of Polymers (2-2)3
[PL 403]

Dynamic mechanical behavior, interrelations between various properties, electrical behavior, miscellaneous mechanical properties, optical properties.

PL 405 Methods of Polymer Characterization (2-0)2
[Open to seniors only]

Survey of physical techniques used in the characterization of polymeric materials with respect to molecular weight, molecular weight distribution, stereo regularity, branching, glass and other transitions, ordering, crystallinity, orientation, fine structure and cross linking.

PL 406 Polymer Structure (3-0)3
[Permission of Instructor]

The fundamental relationships between molecular structure, properties and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical composition, molecular size and flexibility, intermolecular order and binding, and supermolecular structure. Properties include processability, mechanical, acoustic, thermal, electrical, optical and chemical properties, price, and balance of properties. Applications include rigid solids, flexible solids, foams, films, and non-plastic applications.

PL 409 Senior Research in Plastics (1-6)3
[Permission of Instructor]

Individual research projects in plastics chemistry, properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs and submit final reports for publication.

PL 410 Senior Research in Plastics (1-6)3

Continuation of PL 409.

PL 411 Plastics Seminar (1-0)1

Informal discussions based on literature study conducted by the individual of topics in or related to Plastics Technology.

PL 412 Plastics Seminar (1-0)1

A continuation of PL 411.

PL 413 Senior Projects I (0-2)1

Assignment of senior projects designed to develop the student's ability to organize and conduct investigations of materials performance and processing techniques.

PL 414 Senior Projects II (0-2)1

A continuation of PL 413.

PL 502 New Plastics Processing Techniques (3-0)3
[Permission of Instructor]

Critical examination of new plastics processing techniques appearing in the research literature and being commercialized in the plastics industry.

PL 503 Mechanical Behavior of Polymers (3-0)3
[Permission of Instructor]

Mechanical properties of bulk polymers as a class of engineering materials. Linear viscoelasticity and its application to relaxation, creep, dynamic and stress/strain response phenomena. The principles of time/temperature superposition, the relation between the chemical/physical structure of polymers and their utilization as plastics, elastomers, and fibers. Survey of methods of molecular characterization. The effect of molecular weight, molecular weight distribution, branching, cross-linking, order and crystallinity on bulk properties. Statistical mechanical formulation of rubber elasticity. Ultimate and/or failure behavior of polymeric materials and their interpretation on the molecular level.

PL 504 Processing, Morphology, and Properties (3-0)3
[Prerequisite: PL 503]

Effect of processing conditions on polymer fine structure and morphology, and the attendant changes in mechanical and physical properties. Theoretical interpretation of the interrelationships involved.

PL 507 Plastics Industry Organization (3-0)3
[Permission of Instructor]

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing, and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit and growth.

PL 509-510 Plastics Processing Theory (3-0) (3-0)6
[Permission of Instructor]

Principles of heat transfer, rheology, mixing, crystallization, and chemical reactions involved in the processing of plastics, and their applications to plastics process engineering.

PL 511 Multiphase Polymer Systems (3-0)3
[Permission of Instructor]

Compatibility of polymer blends, block and graft copolymers. Morphology of semicompatible systems, and theoretical relationships between structure and properties. Practical systems in development and production.

PL 512 Plastics Foams (3-0)3

[Permission of Instructor]

Preparation, structure, and properties of plastics foams. Practical systems in development and production. Properties, applications, and markets for plastics foams and products made from them.

PL 513 New Plastics Materials (3-0)3

[Permission of Instructor]

Critical examination of the new plastics materials appearing in the research literature and being field-tested for commercialization in the plastics industry.

PL 516 Composite Materials (3-0)3

[Permission of Instructor]

The potential of composites as a class of materials, and the uniqueness of the mechanical/physical properties realizable. Fundamental concepts underlying those properties, with particular emphasis on fibrous reinforced plastics. Survey of matrices, reinforcements, and prediction of composite properties from a knowledge of the properties from a knowledge of the properties and topology of constituent materials. Factors affecting ultimate strength and fatigue behavior.

PL 518 Product Design (3-0)3

[Permission of Instructor]

Theoretical principles and sound engineering practice involved in the design of new end products made from polymers, applying the total systems approach to the balance between product design, choice of materials, and process technique, as they affect competitive choice for commercial success.

PL 519 Plastics Characterization (2-0)2

[Permission of Instructor]

Survey of the leading physico-chemical techniques for characterizing the composition, structure, and morphology of polymer molecules and polymer systems.

PL 521 Polymerization Engineering (3-0)3

[Permission of Instructor]

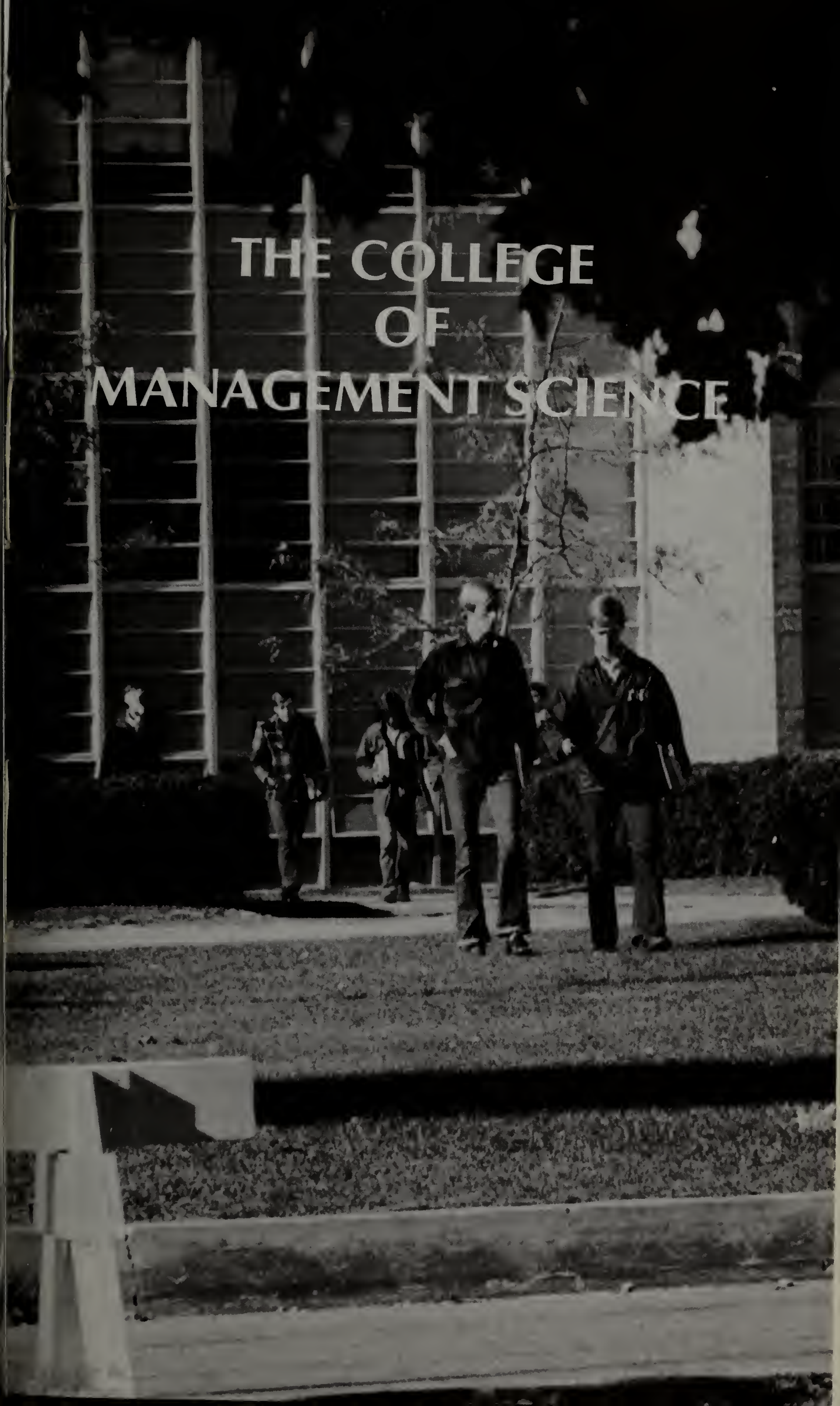
Engineering design of equipment and plants for polymer production. Processes for production of each of the major commercial polymers.

PL 524 Process Analysis, Instrumentation, and Control (3-0)3

[Permission of Instructor]

Industrial instruments for measurement and control of plastics processes. Design of experiments. Analysis of plastics forming operations. Dynamic testing techniques. Automatic plastics process control. Modeling and process simulation in extrusion and injection molding. Data acquisition systems.

THE COLLEGE OF MANAGEMENT SCIENCE



THE COLLEGE OF MANAGEMENT SCIENCE

Business Administration

The undergraduate degree programs in business administration are designed to impart the particular knowledge and specific understanding that will enable the student, upon graduation, either to enter his first professional employment or to embark on a successful program of graduate or professional study. The curricula seek to expand capacities, perspectives, and skills of students who wish careers in either business firms or public service.

The first two years of the undergraduate business program help the student to understand himself, society, and the physical universe; to develop an awareness of moral values; and to enlarge his sense of social responsibility. At the same time, a sound academic foundation is being constructed for his or her second two years of professional course work and specialization. During the freshman and sophomore years, the student will be introduced to accounting, economics, and business law, and expand his knowledge of mathematical analysis.

In the third year, each student is required to take those courses termed "the common body of knowledge," and, with the assistance of a Faculty Advisor, to select an area of concentration. Specialization is currently possible in accounting, economics, and management. The management concentration is further subdivided into financial, marketing and operations (production) management.

There is great opportunity for diversity of interest in the senior year. Since there are few required courses, the student is able to specialize further in his concentration area or, alternatively, to sample other areas of possible interest. Courses in the liberal arts are required throughout the four years to broaden the background of those who aspire to business or professional leadership.

Industrial Management

The undergraduate curriculum in industrial management reflects the unique position of the College in a technological university. This well-established program permits a student to combine the basic elements of an engineering education with a solid grounding in operations management.

The graduate of this curriculum is well-equipped to handle various managerial responsibilities in a technologically-oriented firm. While he is not expected to be a design engineer, he will be able to sell to, buy for, or manage engineers or production activities.

Accordingly, the Industrial Management curriculum is designed to provide a student with a sound foundation in pure science and mathematics, in the humanities, and in the social sciences. In addition, the core subjects of management — accounting, finance, marketing and production — are required. Courses in the various areas of engineering science are taken with major emphasis in the last two years in operations management and research. Some specialization is provided in the junior and senior years under the guidance of a Faculty Advisor.

Master of Management Science

Information on the Master of Management Science degree program can be found in the current issue of the Graduate School catalogue.

Accreditation

The College is a member of the American Assembly of Collegiate Schools of Business.


DATA 3150

FACULTY

Daniel E. Diamond, A.B., M.B.A., Ph.D., Dean

Members

Jack D. Alexander, B.S. in B.A., M.A., M.A. (University of Notre Dame), M.B.A. (Harvard University), Ph.D. (University of Notre Dame), Associate Professor of Management

William J. Burke, B.A. (University of Massachusetts), M.Ed. (Boston State College), J.D. (Suffolk University), Associate Professor of Management

Albert M. Cederlund, A.B. (Clark University), M.S. (Columbia University), Associate Professor of Economics

Samuel Chesler, B.S. in B.A. (Boston University), M.B.A. (Suffolk University), Assistant Professor of Accounting and Finance

Leslie M. Dawson, B.B.A. (Iona College), M.A. (University of Toledo), Ph.D. (Michigan State University), Associate Professor of Management

George C. Dery, A.B. (Merrimack College), M.A. (Boston College), Assistant Professor of Economics

Daniel E. Diamond, A.B. (University of Massachusetts), M.B.A. (Boston University), Ph.D. (New York University), Professor of Economics

Gerald F. Downey, B.S., M.B.A. (Northeastern University), M.A., Ph.D. (Boston College), Assistant Professor of Accounting and Finance

David B. Eastwood, A.B. (Hanover College), M.A. (Brown University), Ph.D. (Tufts University), Instructor of Economics

Charles F. Feeney, B.S. in B.A. (Boston College), M.B.A. (Northeastern University), C.P.A., Assistant Professor of Accounting and Finance

Susan A. Goodwin, B.A. (Wellesley College), M.A. (Boston University), Instructor of Economics

Richard C. Healy, Jr., B.S. in B.A. (American International College), M.A. (University of Massachusetts), Assistant Professor of Economics

Brackston Hinchey, A.B., M.A., Ph.D. (University of Missouri), Associate Professor of Economics (on leave 2nd semester)

Linda H. Kistler, B.S. in B.A., M.S. in B.A. (Colorado State University), C.P.A., Associate Professor of Accounting and Finance

Goang-Tzer Liaw, B.A. (National Taiwan University), M.A. (University of Minnesota), Ph.D. (University of Illinois), Instructor of Management

James C. Lillis, B.S. (Tufts University), M.B.A. (Harvard University), P.E. (Massachusetts), Professor of Management

Thomas G. Macbeth, A.B. (Cornell University), M.A., Ph.D. (University of Southern California), Professor of Economics

Stuart L. Mandell, A.B. (Brooklyn College), M.B.A. (Syracuse University), Professor of Management.

Carol C. Mc'Donough, B.A. (Marymount College), M.A., Ph.D. (Boston College), Assistant Professor of Economics

Cadman D.A. Mills, B.A. (Brandeis University), Ph.D. (Boston College), Instructor of Economics (On Leave)

Terence M. Murphy, B.S. in B.A. (Merrimack College), M.B.A. (Suffolk University), Instructor of Management

Thomas Murphy, A.B. (Boston College), M.B.A. (Harvard University), Associate Professor of Management

Santo J. Pullara, B.S., M.B.A., J.D., Ph.D. (Syracuse University), Professor of Accounting and Finance

Charles L. Saccardo, B.S. in B.A. (Northeastern University), M.A. (Georgetown University), Assistant Professor of Economics

Irwin A. Shapiro, B.S. in B.A. (Syracuse University), M.B.A. (Indiana University), M.A. (Clerk University), Assistant Professor of Management

Rebecca M. Shubert, B.A. (Mount Holyoke College), M.A. (University of Connecticut), Instructor of Economics

Paul E. Snoonian, B.S., M.B.A. (Northeastern University), M.A., Ph.D. (Michigan State University), Assistant Professor of Economics

Charles F. Thompson, B.S.A. (Bentley College), M.B.A. (Northeastern University), C.P.A., Assistant Professor of Accounting and Finance

George J. Toscano, B.S., M.B.A. (Northeastern University), C.P.A., Professor of Accounting and Finance

Louis E. Yelle, B.S. (Lowell Technological Institute), M.S.I.E., M.B.A. (Northeastern University), Assistant Professor of Management

BUSINESS ADMINISTRATION PROGRAM

LOWER DIVISION
(COMMON TO ALL MAJORS)

FRESHMAN YEAR

First Semester

LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
PE	101	Physical Education*	(0-2)1
SS	303	Psychology	(3-0)3
SS		History or Government Elective	(3-0)3
		Science Elective	(3-0)3
		Total hours	(15-2)16

Second Semester

LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
PE	102	Physical Education*	(0-2)1
SS	305	Sociology	(3-0)3
SS		History or Government Elective	(3-0)3
		Science Elective	(3-0)3
		Total hours	(15-2)16

*All nonveteran students who are physically qualified must take physical education.

Students who elect to take the four-year AFROTC program must take the first three years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the senior year may be substituted for general electives. See the section of the catalogue describing the AFROTC program for further details.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	362	Business Law	(3-0)3
EC	201	Economics I	(3-0)3
LL		English Elective*	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Total hours	(15-0)15

*It is recommended that students take LL 207 Oral Business Communications, and LL 210 Technical and Scientific Communication. Students who plan to major in economics should take LL 311 Creative Writing and Advanced Composition. These courses can be taken either semester.

Second Semester

BA	142	Accounting II	(3-0)3
EC	202	Economics II	(3-0)3
EC	211	Economic Statistics I	(3-0)3
LL		English Elective	(3-0)3
MA	242	Electronic Data Processing	(3-0)3
		Total Hours	(15-0)15

UPPER DIVISION
ACCOUNTING MAJORS

JUNIOR YEAR

First Semester

BA	241	Accounting III	(3-0)3
BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Operations Management I	(3-0)3
EC	212	Economic Statistics II	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	242	Accounting IV	(3-0)3
BA	332	Money and Banking	(3-0)3
BA	344	Cost Accounting	(3-0)3
BA	453	Organizational Behavior	(3-0)3
EC	402	Government and Business	(3-0)3
		Total hours	(15-0)15

SENIOR YEAR

First Semester

BA	341	Accounting V	(3-0)3
BA		Accounting Elective	(3-0)3
EC	412	Managerial Economics	(3-0)3
		General Elective or R.O.T.C.	3
		Humanities Elective	(3-0)3
		Total credit hours	15

Second Semester

BA	498	Business Policy	(3-0)3
BA		Accounting Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	15

ECONOMICS MAJORS

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Operations Management I	(3-0)3
EC	212	Economic Statistics II	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	332	Money and Banking	(3-0)3
BA	453	Organizational Behavior	(3-0)3
EC	304	Macroeconomic Theory	(3-0)3
EC	402	Government and Business	(3-0)3
EC		Economics Elective	(3-0)3
		Total hours	(15-0)15

SENIOR YEAR

First Semester

EC	412	Managerial Economics	(3-0)3
EC		Economics Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	(15-0)15

Second Semester

BA	498	Business Policy	(3-0)3
EC		Economics Elective	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	15

MANAGEMENT MAJORS

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Operations Management I	(3-0)3
EC	212	Economic Statistics II	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	346	Managerial Accounting	(3-0)3
BA	453	Organizational Behavior	(3-0)3
EC	402	Government and Business	(3-0)3
		Management Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

SENIOR YEAR

First Semester

EC	412	Managerial Economics	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		Management Elective	(3-0)3
		General Elective	(3-0)3
		Total credit hours	(15-0)15

Second Semester

BA	498	Business Policy	(3-0)3
		General Elective or R.O.T.C.	3
		Management Elective	(3-0)3
		General Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total credit hours	15

Notes on electives:

General elective: refers to any course given at the Institute. Courses given in other colleges of the Institute that duplicate courses taken by the student in the College of Management Science are not acceptable.

Humanities elective: refers to any course bearing an EC, LL or SS designation.

Management elective: refers to any course bearing a BA or EC designation. Courses in the behavioral science areas are acceptable with permission.

FRESHMAN YEAR

First Semester

EC	201	Economics I	(3-0)3
FS	001	Freshman Seminar	(1-0)0
LL	111	English I	(3-0)3
MA	131	College Math I	(4-0)4
ME	201	Graphics	(1-0)1
PE	101	Physical Education*	(0-2)1
PH	141	Physics	(3-1)3
		Total hours	(15-3)15

Second Semester

EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	132	College Math II	(4-0)4
ME	271	Machine Tool Laboratory	(1-3)2
PE	102	Physical Education*	(0-2)1
PH	142	Physics	(3-1)3
		Total hours	(14-6)16

*All nonveteran students who are physically qualified must take physical education.

Students who elect to take the four-year AFROTC program must take the first three years in addition to the other required subjects. A maximum of six credit hours of the Professional Officer Course in the senior year may be substituted for general electives. See the section of the catalogue describing the AFROTC program for further details.

SOPHOMORE YEAR

First Semester

BA	143	Accounting Management I	(3-0)3
CH	121	Chemical Principles	(3-0)3
CH	123	Chemical Principles Laboratory	(0-2)1
MA	231	College Math III	(4-0)4
PH	241	Physics	(4-2)4
		Total hours	(14-4)15

Second Semester

BA	144	Accounting Management II	(3-0)3
CH	122	Chemical Principles	(4-0)3
CH	124	Chemical Principles Laboratory	(0-2)1
EC	211	Economic Statistics I	(3-0)3
LL	210	Technical & Scientific Communication	(3-0)3
MA	232	College Math IV	(4-0)4
		Total hours	(17-2)17

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Business Finance	(3-0)3
BA	371	Operations Management I	(3-0)3
EC	212	Economic Statistics II	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
		Total hours	(17-0)17

Second Semester

MA	242	Electronic Data Processing	(3-0)3
BA	474	Operations Management IV	(3-0)3
BA	476	Statistical Quality Control	(3-0)3
ME	372	Strength of Materials	(3-0)3
		General Elective	3
		Total credit hours	15

SENIOR YEAR

First Semester

BA	404	Computer Applications to Management	(3-0)3
BA	451	Personnel Management	(3-0)3
EE	351	Industrial Electronics	(3-0)3
MA	381	Operations Research	(3-0)3
		General Elective or ROTC	3
		BA or EC Elective	3
		Total credit hours	18

Second Semester

BA	498	Business Policy	(3-0)3
MA	382	Operations Research	(3-0)3
ME	344	Heat and Power	(3-0)3
		General Elective or ROTC	3
		BA or EC Elective	3
		Total credit hours	15

BUSINESS ADMINISTRATION COURSE DESCRPTIONS

BA 141-142 Accounting I and II (3-0) (3-0)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 143-144 Accounting Management I and II (3-0) (3-0) 6
[Not For B.A. Students]

These courses are designed to give the industrial management student an understanding of accounting concepts and techniques. Special emphasis on the role of cost accounting in the manufacturing process.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3
[EC 201]

An analysis of the marketing of goods and services to final consumers and intermediate customers. The study of decision areas such as product planning, channels of distribution, promotion, and pricing is based upon a framework of consumer behavior, environmental forces, governmental constraints, and the existing structure of business institutions involved.

BA 324 Industrial Marketing (3-0)3
[BA 321]

Special problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing strategy. Cases will be used.

BA 325 Advertising (3-0)3
[BA 321]

Commencing on a foundation of the historical evolution of advertising and the economic and social role of promotion, this course takes in an in-depth look at advertisers, advertising agencies, and media as well as advertising creation and evaluation.

BA 326 **Marketing Research** **(3-0)3**
[BA 321, EC 211]

The process of planning, executing, and evaluating marketing research which is the information-gathering function of marketing management.

BA 331 **Business Finance** **(3-0)3**
[BA 142, EC 202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 **Money and Banking** **(3-0)3**
[EC 202]

The evolution of money and credit and their role in the economy. Monetary policies of the Federal Reserve System. The structure and operation of the commercial banking system and the creation of money. The role of other financial institutions and their effect on the economy.

BA 334 **Investment Management** **(3-0)3**
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 **Accounting V and VI** **(3-0) (3-0)6**
[BA 242]

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(3-0)3**
[BA 142]

An examination of the manufacturing function from the view of the cost accountant. Managerial control of the elements of costs will be studied with an emphasis on job lot and process cost accounting systems.

BA 346 **Managerial Accounting** **(3-0)3**
[BA 142]
[For Non-accounting Majors]

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 **Business Law** **(3-0)3**

Principles of commercial law encompassing a study of contracts, agency, employment, commercial paper and sales including the Uniform Commercial Code.

BA 363 **Advanced Business Law** **(3-0)3**

[BA 362]

The analysis of the legal principles underlying real and personal property, corporations, partnerships, trusts and estates.

BA 371 **Operations Management I** **(3-0)3**

Principles of manufacturing organization and productive processes with emphasis placed upon the functions of production systems; operational planning and control; plant layout; materials handling; inventory and quality control.

BA 372 **Operations Management II** **(3-0)3**

[BA 371]

A case course in the application of the principles covered in BA 371. The cases are representative of a wide range of products and industries. Small, medium and large manufacturing enterprises are studied; consideration is given to intermittent, continuous, and job lot systems of production.

BA 402 **International Business** **(3-0)3**

[BA 321, 331 and EC 202]

A study of the special problems relating to international management. Emphasis is placed upon the overseas operations of American firms including finance, marketing, personnel, and legal problems. Additional topics include state trading, economic integration, and international regulatory agencies.

BA 404 **Computer Applications to Management** **(3-0)3**

[MA 202]

An investigation of the applications of electronic computers in the management of business enterprises. Attention is given to problems of management under conditions of uncertainty, inventory and production control, queuing theory, linear and nonlinear programming.

BA 421 **Procurement** **(3-0)3**

[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 422 **Retailing** **(3-0)3**

[BA 321]

The development, organization, and management of retailing institutions. Students will compare and evaluate various types of firms and current problems in the field.

BA 423 **Marketing Management** **(3-0)3**
[BA 321 and BA 326]

Analyzes the process wherein the marketing strategies and plans of a competitive firm are formulated, implemented, and adjusted over time. Utilizes cases to study the behavioral, quantitave, and environmental aspects of marketing decision-making.

BA 426 **Sales Management** **(3-0)3**
[BA 321]

Analyzes the management of the personal selling function in its broadest aspects. Topics include sales force organization, selection, training, compensation, supervision, and motivation. Cases are used to emphasize the application of general principles to actual management problems.

BA 428 **International Marketing** **(3-0)3**
[BA 402]

A study of those aspects of marketing which are unique to international business. Subjects include cultural dynamics, economic, political, and legal environmental constraints, and international marketing institutions and practices.

BA 431 **Financial Management** **(3-0)3**
[BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 432 **Financial Institutions and Markets** **(3-0)3**
[BA 331, 332]

This course covers the theoretical and pragmatic aspects of the financial process in our economic system. Financial intermediation as accomplished through institutions and markets is thoroughly analyzed.

BA 433 **Contemporary Problems in Finance** **(3-0)3**
[BA 331, 332]

A seminar in which one or more specialized topics are studied.

BA 441 **Auditing** **(3-0)3**
[BA 242]

Auditing will be studied through the use of current professional literature and selected case studies. Current auditing standards, practices and problems are examined in detail. The course will stress conceptual understanding rather than procedural problem solving.

BA 442 **Advanced Public Accounting** **(3-0)3**
[BA 441]

An examination of the controversial areas of public account-

ing with special attention on the professional and technical aspects of practice. The course will include a study of systems and procedures engagements, auditing data procession, S.E.C. audits, and management services.

BA 444 Advanced Cost Accounting (3-0)3

[BA 344]

Topics covered will include standard (estimated) costs, variance analysis, profit planning, cost-volume-profit analysis, and relevant cost analysis for problem solving.

BA 445 Federal Income Taxes (3-0)3

[BA 142]

This course deals with the basic rules and regulations of the Internal Revenue Code as it affects the individual and the corporation. An understanding of the code is developed through lectures, assigned readings, research, and the solution of a wide variety of problems.

BA 448 Seminar in Accounting (3-0)3

[For Accounting Seniors Only]

Readings on contemporary accounting problems, controversies in current accounting practice and computer utilization in accounting systems comprise the foundation of the seminar. Extensive use is made of cases to illustrate problem areas in current accounting practice. Written and oral defense of case conclusions are important aspects of the course.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 Industrial Relations (3-0)3

[BA 451 or 453]

Human interaction and group behavior in organized industrial settings; union-management relations; grievance procedures and arbitration; job evaluation; motivation and leadership.

BA 453 Organizational Behavior (3-0)3

Basic findings and concepts of the behavioral sciences will be related to the specific aspects of behavior in organizations. Individual and group behavior will be examined. The process of improving and achieving change in organizations using behavioral concepts will be explored.

BA 471 Analytical Methods in Management (3-0)3

[BA 321, BA 331, BA 371]

[Not for IM Majors]

A survey of the quantitative techniques available to assist management in the decision making process. Applications in the

functional areas of marketing, production, and finance will be explored.

BA 472 Management of Organizations (3-0)3
[BA 451 or 453]

The course treats managing and organizations as interrelated dynamic decision processes and systems. It is concerned with values, communications, interactions, as well as with resources, environment and people. Varying organizational structures and their content are examined, including those in the public, voluntary, and business fields.

BA 473 Operations Management III (3-0)3
[BA 371]
[Formerly IM 371]

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

BA 474 Operations Management IV (3-0)3
[BA 473 or MA 232]
[Formerly IM 372]

A quantitatively oriented case course stressing the functional interrelationship of major manufacturing decisions facing management. Emphasis will be placed on problems of operations management, including scheduling, inventory control and facilities design, and methods of implementation, applied theory of mathematical programming, simulation, statistical models and organizations design.

BA 476 Statistical Quality Control (3-0)3
[MA 283 or EC 212]
[Formerly IM 483]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

BA 481 Insurance (3-0)3

Principles of risk and risk management. Emphasis on life, health, fire, and casualty insurance as methods of handling risks.

BA 492 Physical Distribution Management (3-0)3

Emphasis on the analytical needs involved in the management of the functions that comprise physical distribution: warehousing, inventory control, materials handling, and industrial packaging. Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies in the United States.

BA 498 **Business Policy** **(3-0)3**

[Seniors in BA and IM only]

A study of the functions and responsibilities of general management and their interrelationships. Consideration will be given to the problems which affect the character and success of the total enterprise. Emphasis will be placed on corporate strategy the setting of objectives, establishing policies, and structuring the enterprise.

BA 499 **Research Seminar** **3**

[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

ECONOMICS COURSE DESCRIPTIONS

EC 201 **Economics I** **(3-0)3**

A study of the principles governing the production and exchange of goods and services.

EC 202 **Economics II** **(3-0)3**

A study of the principles governing the level of national income and employment. Examination of the commercial banking system, monetary and fiscal policy, the international economy, and alternative economic systems.

EC 211 **Economic Statistics I** **(3-0)3**

Descriptive statistics, sophisticated counting techniques and other components of probability, simple random variables and their distributions, bivariate functions, sampling theory, properties of estimators, maximum likelihood estimation, confidence intervals, and hypothesis testing.

EC 212 **Economic Statistics II** **(3-0)3**

[EC 211]

Analysis of variance, regression theory, multiple regression, correlation, and decision theory.

EC 302 **Labor Economics** **(3-0)3**

[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 **Microeconomic Theory** **(3-0)3**

[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 Macroeconomic Theory (3-0)3
[EC 202]

An analysis of Keynesian and Post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 305 Regional Economics (3-0)3
[EC 202]

An introductory approach and survey of theories of location of firms, industries and population. Regional income accounting systems and intra/interregional income models.

EC 306 Urban Economics (3-0)3
[EC 202]

An introduction to urban economics. Analysis of intra-metropolitan spatial relationships including residential location and land and housing markets.

EC 307 Economic Analysis of Urban Problems (3-0)3
[EC 202]

Analysis of the economic structure of urban areas. The tools of economic analysis are applied to urban problems such as poverty, transportation, education, pollution and the financing of urban government.

EC 401 Current Problems (3-0)3
[EC 303, BA 332, EC 402]

A seminar on selected problems which confront the contemporary American economy.

EC 402 Government and Business (3-0)3
[EC 202, BA 332]

An examination of the various governmental controls over business in the American economy. Emphasis on court interpretations of the antitrust laws and on the economic theory and political philosophy behind them.

EC 403 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 Comparative Economic Systems (3-0)3
[EC 303, BA 332]

Analysis of free-market and planned economies in theory and practice. Emphasis on the United States and the Soviet Union.

EC 405 Marxism and the Soviet Economy (3-0)3

The economic system of Marx: dialectic materialism and Marx's economic model of capitalism. The contemporary Soviet example is considered with an emphasis on the economic planning process and the current system of incentives and success indicators.

EC 406 Welfare Economics (3-0)3

[EC 303]

An evaluation of Pareto Optimality and the Hicks-Kaldor Compensation Principle. Divergence from the purely competitive norm and the Theory of the Second Best. Discussion of the Arrow Impossibility Theorem.

EC 407 Econometrics (3-0)3

[EC 212, EC 304]

The course will provide the student both theoretical and empirical knowledge of econometrics. Methods of handling data, quantitative empirical estimates, and tests of economic theory.

EC 408 History of Economic Thought (3-0)3

[EC 303]

The rise of classical growth and value theories. The evolution of neoclassical theories of price and distribution, and the development of welfare criteria. A comparison of Keynesian and classical macroeconomic theory. The role of economic analysis in the post-Keynesian world.

EC 409 Growth Theory (3-0)3

[EC 304, EC 311]

BA 332Analysis of cyclical fluctuations and long-term economic growth. Construction of economic growth models.

EC 410 Economic Development of Less Developed Countries (3-0)3

[EC 202]

The role of capital (private and social), technology, labor, governemnts, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 Public Finance (3-0)3

[EC 303, EC 304]

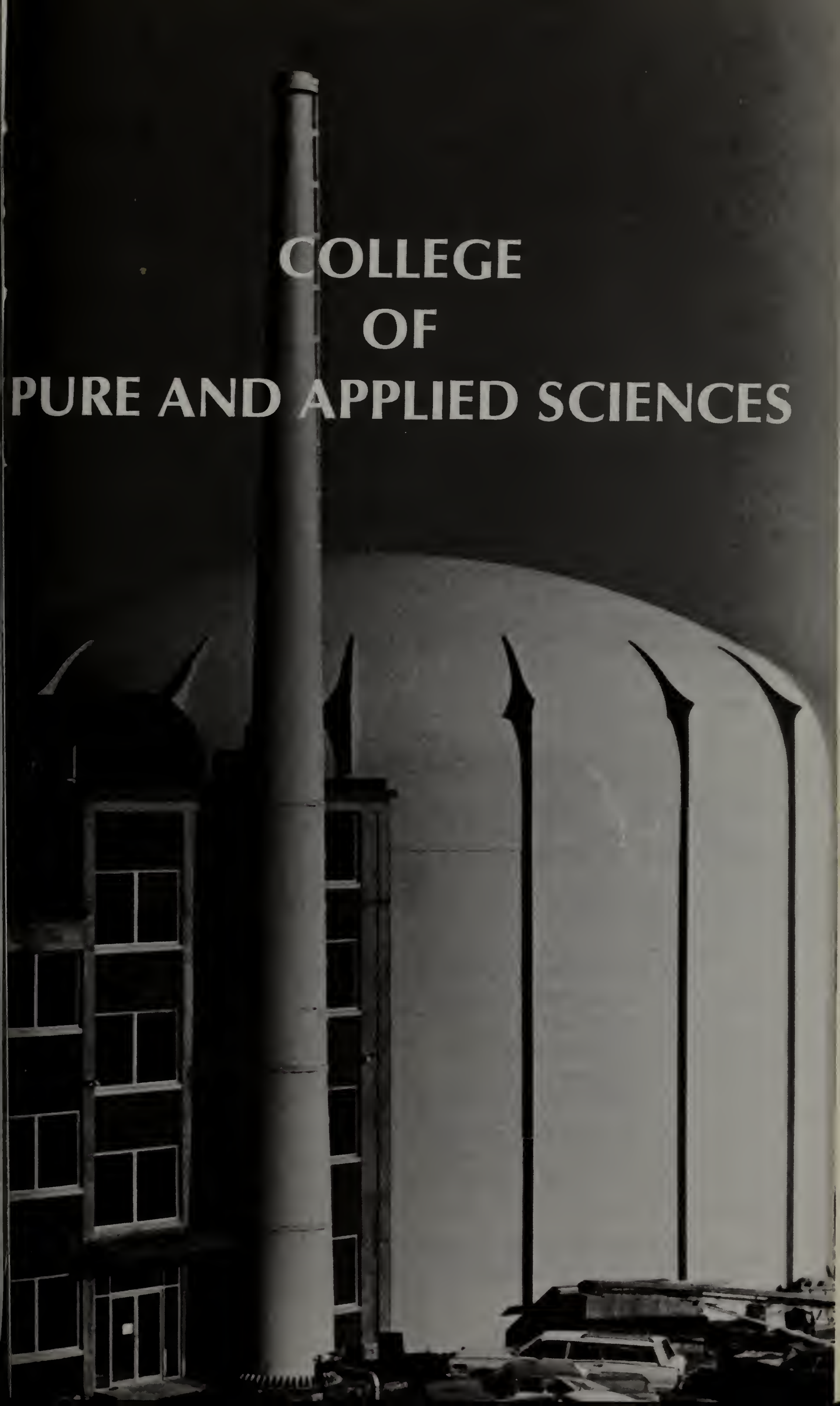
The economics of the public sector. Principles of public expenditure, taxation, and the public debt applied to federal, state, and local governments.

EC 412 **Managerial Economics** **(3-0)3**
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 499 **Research Seminar** **(3-0)3**
[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.


COLLEGE
OF
PURE AND APPLIED SCIENCES

COLLEGE OF PURE AND APPLIED SCIENCES

The College of Pure and Applied Science offers programs which enable the student to acquire a broad preparation for life in a technological society, to obtain a sound basis for his professional education, and to receive training in specific skills required for service in his chosen field of endeavor.

The courses offered in the College provide the student with an opportunity to understand the problems of the past and the solutions thereof achieved, to understand the present state of knowledge, and to develop habits of analytical thought and mental discipline necessary for the definition and solution of present and future problems.

Students intending to terminate their formal education at the bachelor level will find that they are prepared for a broad spectrum of technical positions in industry and government, while those who intend to go on to higher degrees will find that they have been well prepared for further study in graduate and professional schools.

Generally speaking, only those students who have had a definite interest in and proficiency in high school science and mathematics should enter study in the College.

The student may enroll in any one of the following curricula:

- Biological Sciences
- Chemistry
- Mathematics
- Meteorology
- Nuclear Engineering
- Physics and Applied Physics
- Radiological Health Physics

Students desiring to enroll in one of these curricula should consult with the department involved.

FACULTY

Leon E. Beghian, B.A., Ph.D., Acting Dean

Chairmen of Departments

Robert M. Coleman, B.S., M.S., Ph.D., Biological Sciences

Robert C. Curtis, A.B., Ph.D., Meteorology

Gunter H.R. Kegel, F.N.Fi., Ph.D., Physics and Applied Physics

Philip S. Lamprey, B.S., Ph.D., Chemistry

Kenneth W. Skrable, B.S., M.S., Ph.D., Radiological Sciences

Jacob Weinberg, B.S., S.M., Ph.D., Mathematics

Members

Biological Sciences

Robert M. Coleman, B.S. (Bates College), M.S. (University of New Hampshire), Ph.D. (University of Notre Dame), Professor

Timothy Macdonald, B.A., Ph.D. (University of Hawaii), Assistant Professor

John C. Mallett, B.S. (College of the Holy Cross), M.S., Ph.D. (University of Rhode Island), Instructor

Patricia G. Mulhall, B.S. (Utica College of Syracuse University), M.S. (Rensselaer Polytechnic Institute), Assistant Professor

Nicholas J. Rencricca, B.S. (St. Francis College), M.S. (St. John's University), Ph.D. (Boston College), Assistant Professor

Chemistry

William W. Bannister, B.S., Ph.D. (Purdue University), Associate Professor

Eugene F. Barry, Jr., B.S. (Villanova University), Ph.D. (University of Rhode Island), Instructor

Alexandre Blumstein, B.S. (Sorbonne), Ph.D. (Strasbourg University), Professor

Barbara L. Brooks, B.S. (Lowell Technological Institute), Instructor

Stuart B. Clough, B.S. (University of Massachusetts), M. Ch.E. (University of Delaware), Ph.D. (University of Massachusetts), Assistant Professor

Charles L. Daley, B.T.C. (Lowell Technological Institute), Professor

George R. Griffin, B.S. (Indiana University), M.A. (Boston University), Ph.D. (Massachusetts Institute of Technology), Professor

Martin Isaks, B.S. (Purdue University), M.S. (Iowa State University), Ph.D. (University of Cincinnati), Associate Professor

Stanley C. Israel, B.S. (Parsons College), Ph.D. (Lowell Technological Institute), Assistant Professor

Ernest P. James, B.T.C., M.S. (Lowell Technological Institute), Professor and Director of Continuing Education and Summer School

Albert D. Kowalak, B.S. (College of William and Mary), M.S., Ph.D. (Virginia Polytechnic Institute), Associate Professor

Philip S. Lamprey, B.S. (Lowell Technological Institute), Ph.D. (University of New Hampshire), Professor

Vasilis Lavrakas, B.S. (University of Massachusetts), M.S. (Tufts University), Professor

Irving Lipschitz, B.A., M.S. (New York University), Ph.D. (Virginia Polytechnic Institute), Assistant Professor

Robert J. Peirent, B.S., M.S. (Lowell Technological Institute), Professor

James B. Pierce, B.S. (Thiel College), M.S., Ph.D. (Case Institute of Technology), Professor

Rita Blumstein, B.Sc. (University of Paris), M.S. (Strasbourg University), Ph.D. (University of Delaware), Adjunct Associate Professor

Chong Wha Pyun, B.S., M.S. (Seoul National University), Ph.D. (Brown University), Associate Professor

Harry Rubinstein, B.S. (Brooklyn College), Ph.D. (Purdue University), Professor

Joseph C. Salamone, B.Sc. (Hofstra University), Ph.D. (Polytechnic Institute of Brooklyn), Assistant Professor

Allen Scattergood, A.B. (Columbia University), Ph.D. (Princeton University), Professor

Sami A. Shama, B.Sc. (Cairo University), M.S. (Lowell Technological Institute), Instructor

Judith A. Tilden, B.A. (Emmanuel College), M.S. (Lowell Technological Institute), Instructor

Arthur C. Watterson, Jr., B.S. (Geneva College), Ph.D. (Brown University), Professor (on leave 2nd semester)

Charles R. Wilson, B.S. (Lowell Technological Institute), Instructor

Mathematics

Donald L. Ameen, B.S. (Lowell Technological Institute), M.S. (Cornell University), Assistant Professor

Edward F. Baldyga, B.A., M.A. (University of Connecticut), Instructor

Maurice Beren, B.S. (Massachusetts Institute of Technology), Instructor

Stephen J. Bodor, B.S., M.S. (Lowell Technological Institute), Professor

Pasquale Condo, B.S. (Purdue University), M.S. (Lowell Technological Institute), Assistant Professor

Angelo Dadoly, B.S. (Boston University), M.Ed. (Boston State College), Assistant Professor

Robert K. Devejian, B.S. (Tufts University), M.A. (Boston University), Professor

Alan W. Doerr, B.A. (Marist College), M.A. (Hunter College), Assistant Professor

James H. Doherty, B.A. (University of New Hampshire), M.S. (Lowell Technological Institute) Associate Professor

M. Brendan Fleming, B.S., M.A. (Boston College), Professor

Michael Grossman, B.S. (Tufts University), M.A. (Yale University), Assistant Professor

Mary C. Hall, A.B. (Regis College), M.Ed. (Boston University), Associate Professor

Ann Marie Hurley, A.B. (Emmanuel College), Instructor

Alan Kaplan, B.S. (University of Massachusetts), M.S., Ph.D. (Syracuse University), Assistant Professor

Thomas G. Kudzma, S.B. (Massachusetts Institute of Technology), A.M. (Harvard University), Assistant Professor

Peter Lindstrom, A.B. (Northeastern University), A.M., Ph.D. (Boston University), Instructor

Thomas F. McElligott, A.B. (Mt. St. Mary's College), Ed.M. (Boston University), Professor

C. Robert Montgomery, B.A. (Boston University), P.E., Assistant Professor

Joseph L. Neuringer, B.A. (Brooklyn College), M.A. (Columbia University), Ph.D. (New York University), Professor

Alexander A. Olsen, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Instructor

Andrew A. Ouellette, B.S. (Brown University), Professor

Ira E. Over, Jr., B.S. (University of Maryland), M.S. (Xavier University), Assistant Professor

Bernard Shapiro, B.S. (Lowell Technological Institute), S.M. (Massachusetts Institute of Technology), Associate Professor

Arthur D. Talkington, B.S. (University of Chicago), M.A. (University of Missouri), Associate Professor

Virginia S. Taylor, B.S. (Syracuse University), M.A. (Western Michigan University), Assistant Professor

Jacob Weinberg, B.S. (Yeshiva University), S.M., Ph.D. (Massachusetts Institute of Technology), Professor

Meteorology

Robert C. Curtis, A.B. (Williams College), Ph.D. (Pennsylvania State University), Professor

Wen Tang, B.S. (National Central University, China), M.S., Ph.D. (New York University), Associate Professor

Physics and Applied Physics

Gunter H. R. Kegel, F.N.Fi (Universidade do Brasil), Ph.D. (Massachusetts Institute of Technology), Professor

Albert Altman, B.S. (Brooklyn College), M.S., Ph.D. (University of Maryland), Professor

Adolph Baker, B.A., M.S. in Ed. (City College of New York), B.M.E. (Brooklyn Polytechnic Institute), M.S. (New York University), Ph.D. (Brandeis University), Professor

Luther C. Barcus, B.A. (University of Delaware), M.S. (Miami University), Associate Professor

Barry K. Barnes, B.A., Ph.D. (Rice University), Assistant Professor

Leon E. Beghian, B.A., Ph.D. (University of Oxford), Professor and Provost

C. Daniel Cole, B.A., M.A., Ph.D. (University of Buffalo), Professor

Gus P. Couchell, B.S., M.S. (North Carolina State University), Ph.D. (Columbia University), Associate Professor

James J. Egan, B.A. (Thomas More College), M.S., Ph.D. (University of Kentucky), Assistant Professor

Ian A. Forbes, B.S. (Memorial University of Newfoundland), Ph.D. (Massachusetts Institute of Technology), Assistant Professor

Zoltan Fried, B.S. (Brooklyn College), Ph.D. (Brandeis University), Professor

F. Raymond Hardy, B.S., M.S. (Lowell Technological Institute), Professor and Director of Freshman Studies

Padmanabh Harihar, B.S. (R. Ruia College), M.S. (Wilson College), Ph.D. (Columbia University), Associate Professor

Lloyd C. Kannenberg, S.B. (Massachusetts Institute of Technology), M.S. (University of Florida), Ph.D. (Northeastern University), Associate Professor

Aram S. Karakashian, B.A., M.A. (Temple University), Ph.D. (University of Maryland), Assistant Professor

David Korff, B.A. (Harvard University), Ph.D. (Brandeis University), Professor

Thomas V. Marcella, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Assistant Professor

Suresh C. Mathur, B.Sc., M.Sc. (University of Lucknow), Ph.D. (University of Texas), Professor and Director of Computer Center

Roger D. McLeod, B.A. (Bowdoin College), M.S. (Lowell Technological Institute), Associate Professor

Walter Roy Mellen, B.S. (Massachusetts Institute of Technology), M.S. (Lowell Technological Institute), Associate Professor

Arthur I. Miller, B.S. (City College of New York), Ph.D. (Massachusetts Institute of Technology), Associate Professor

Arthur Mittler, B.A. (Drew University), M.S., Ph.D. (University of Kentucky), Assistant Professor

M. Ali Omar, B.S. (Colorado School of Mines), MS., M.S., Ph.D. (University of Colorado), Professor

James P. Phelps, B.S. (University of Maine), Ph.D. (Michigan State University), Adjunct Associate Professor and Chief Nuclear Realtor Engineer

David J. Pullen, B.Sc. (King's College, University of London), D. Phil. (Trinity College, University of Oxford), Associate Professor

Paul J. Ring, B.S. (Boston College), M.S., (Rensselaer Polytechnic Institute), Ph.D. (Brown University), Assistant Professor

Alexander Sachs, B.S. (Northwestern University), Instructor

Walter A. Schier, B.S. (St. Procopius College), Ph.D. (University of Notre Dame), Associate Professor

Kunnat J. Sebastian, B.S., M.S. (University of Kerala), Ph.D. (University of Maryland), Assistant Professor

Eric Sheldon, B.Sc., B.Sc., Ph.D., D.Sc. (University of London), Professor

Malcolm K. Smith, B.S. (Haverford College), M.A. (Columbia University), Professor

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Jerry Waldman, B.A., M.A. (Columbia University), Ph.D. (Massachusetts Institute of Technology), Assistant Professor

Martin Wilner, B.S. (Rensselaer Polytechnic Institute), M.S. (Yale University), Ph.D. (Massachusetts Institute of Technology), Professor

Chuen Wong, Dipl of Sci. (Chong Chi College, Hong Kong), Ph.D. (Case Institute of Technology), Assistant Professor

Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), Professor

Radiological Sciences

Edward L. Alexander, B.S., M.S. (University of Maine), Ph.D. (Vanderbilt University), Professor and Dean of the Graduate School

George E. Chabot, Jr., A.B. (Harvard University), M.S. (Harvard School of Public Health), Certified Health Physicist; Adjunct Assistant Professor and Supervisor in Nuclear Center

Jesse Y. Harris, B.S., M.S., Ph.D. (Rutgers University), Professor and Director of King Educational Opportunity Program

Anthony Liuzzi, B.S. (Rensselaer Polytechnic Institute), M.S., Ph.D. (New York University), Certified Health Physicist; Associate Professor

James P. Phelps, B.S. (University of Maine), Ph.D. (Michigan State University), Adjunct Associate Professor and Chief Nuclear Reactor Engineer

Kenneth W. Skrable, B.S. (Moravian College), M.S. (Vanderbilt University), Ph.D. (Rutgers University), Certified Health Physicist; Professor and Chairman

Harold L. Wedlick, B.S., M.S., (Wayne State University), Radiochemistry Supervisor in Nuclear Center and Adjunct Associate Professor

BIOLOGICAL SCIENCES

The Department was established in the fall of 1968 and is presently housed in temporary quarters which have been substantially increased. New facilities are expected to be completed for occupancy during the 1973 academic year. An area of 30,000 sq. ft. has been designed to include teaching laboratories, undergraduate and graduate research facilities, office-research modules and service areas such as animal quarters, rooms for instrumentation, preparation and temperature control as well as X-ray, electron microscope and greenhouse facilities.

The curriculum in the Biological Sciences is designed to provide a sequence of liberal arts and science courses for a sound career foundation. Development of attitudes along with abilities is considered highly significant for a successful career. The importance of a breadth of knowledge and understanding of related scientific disciplines is stressed for greater appreciation and comprehension of biological principles and modern quantitative concepts.

Upon graduation the biology major will find opportunities in teaching, industry, government and the medical services. The curriculum objectives chosen also permit a sound preparation for graduate study in the biological sciences, medicine and dentistry.

Students who have demonstrated high scholastic ability may conduct investigative studies throughout the senior year. Emphasis is placed on completion of an original research project followed by an oral examination of the candidate's undergraduate thesis.

BIOLOGICAL SCIENCES PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA or	131 or 133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	126	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or	134	College Math II or Calculus II	(4-0)4
*PH	142	Physics	(3-1)3
PE	102	Physical Education	(0-2)1
		Total hours	(13-6)15

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE Year

First Semester

BI	201	Principles of Biology	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	231		(4-0)4
or	233	College Math III or Calculus III	or (3-0)3
*PH	243	Physics	(3-1)3
		Total Hours	(13-8)15 or (12-8)14

Second Semester

BI	202	Principles of Biology	(3-3)4
CH	222	Organic Chemistry	(3-4)4
MA	383	Introduction to Statistics	(3-0)3
		Two General Electives**	(6-0)6
		Total Hours	(15-7)17

*PH 247 Honors Physics may be substituted
**LL 333 Problems of Philosophy and SS 303 Psychology are recommended

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
BI	371	Genetics	(3-3)4
CH	335	Principles of Physical Chemistry	(3-0)3
CH	337	Principles of Physical Chemistry Lab	(0-3)1
		Technical Elective	4
		Total Hours	16

Second Semester

BI	306	Biochemistry	(3-3)4
		Biology Elective	(3-3)4
CH	336	Principles of Physical Chemistry	(3-0)3
CH	338	Principles of Physical Chemistry Lab	(0-3)1
		Technical Elective	4
		Total Hours	16

SENIOR YEAR

First Semester

BI	411	Research in Biology or Biology Elective	4
BI	451	Seminar in Biology	(1½-0)1
RS	441	Radioisotope Techniques	(3-3)4
		General Elective	(3-0)3
		Technical Elective or General Elective	3
		Total credit hours	15

Second Semester

BI	412	Research in Biology or Biology Elective	4
BI	452	Seminar in Biology	(1½-0)1
BI	462	Radiation Biology	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective or General Elective	3
		Total credit hours	17

Not more than a total of six credits of junior or senior AS subjects may be substituted for technical or general electives.

BIOLOGICAL SCIENCES COURSE DESCRIPTIONS

BI 201 Principles of Biology (3-3)4
[CH 121, CH 126]

Part one of a basic course which includes an introduction to cell structure, cellular metabolism, molecular genetics, protein synthesis, bacteria and viruses, and systems of the human body.

BI 202 Principles of Biology (3-3)4
[BI 201]

Part two of a basic course dealing with the structure, function, and diversity of living organisms including a brief survey of the animal and plant kingdoms, photosynthesis, developmental biology, population genetics, ecology and evolution.

BI 301 Physiology (3-3)4
[BI 202]

A study of the fundamental mechanisms governing human physiology. The involvement of basic cell function, biological control systems and coordinated body functions in maintaining homeostasis will be discussed in terms of chemical and physical principles.

BI 306 Biochemistry (3-3)4
[CH 222 or 224, CH 232 or 336 concurrently]

Fundamental concepts in biochemistry including protein structure and biosynthesis; enzyme structures and mechanisms; nucleic acids and genetic development, metabolism; photosynthesis, cellular structure; functions and structure of carbohydrates, hormones, lipids, and hemins; chemical functions of organs.

BI 312 Microbiology (3-3)4
[BI 202]

A study of the morphology and the chemical and physical activities of representative bacteria, yeasts, molds, viruses and animal parasites as related to man. The laboratory covers basic qualitative and quantitative techniques of microbiology with an introduction to selected immunochemical methods.

BI 331 Ecology (3-3)4
[BI 202]

A course dealing with factors responsible for the relationships of living organisms to each other and to their natural environment. The nature and dynamics of the biotic community.

BI 332 Botany (3-3)4

An introduction to the plant kingdom dealing with the structure, function, and diversity of the different plant forms. The cy-

tology, ecology, morphology, physiology, and taxonomy of plants will be considered.

BI 371 Genetics (3-3)4

[BI 202]

The laws of biological inheritance. The molecular basis of heredity is stressed. Replication of DNA, genetic codes and fine structures of chromosomes are considered.

BI 411-412 Research in Biology (0-12) (0-12)8

An individual, directed research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration is required.

BI 421 The Environmental Biology of Man (3-0)3

This course will be centered on Man as a biological entity. His chemistry, cellular design, and physiology will be described as well as his requirements for growth, repair, and reproduction. The extent to which he depends on other organisms and on chemicals in his environment to meet these requirements will be outlined. Specific examples will be cited to show direct or indirect imbalances in nature on Man's ability to meet his requirements. The importance of species interaction and their dependence on the physical environment will be emphasized. Not open to Biology majors.

BI 451-452 Seminar in Biology (1½-0) (1½-0)2

Seminar discussion of selected topics of current research interest. Offered each semester by a different member in his special discipline. Student participation in the form of discussion and presentation of papers. For senior biology majors.

BI 456 Endocrinology (3-3)4

[BI 301]

[Offered in alternate years]

Structure and physiology of the endocrine glands. Emphasis will be given to the synthesis, transport, and mechanism of hormone action with regard to regulation of intermediary metabolism and maintenance of an homeostatic microenvironment. Endocrine imbalances, resulting in disease will also be discussed.

BI 462 Radiation Biology (3-3)3

[BI 202, RS 441]

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and late effects in whole animals

and the modification of radiation exposure by physical, chemical and biological factors.

BI 481 Immunobiology (3-3)4
[BI 312]
[Offered in alternate years]

This course deals with the biology of the immune response with sections on antibody production, reaction with antigen, suppression, tolerance, protection and injury.

BI 506 Ecological Physiology (3-3)4
[BI 301, BI 330]

A consideration of physiological, evolutionary and environmental aspects of interactions between organism and environment with special emphasis on homeostatic adaptations to biotic and abiotic environmental fluctuations.

BI 513 Enzymology (3-0)3
[BI 306]

The structure, properties, modes of activation, and mechanisms of action of some specific enzymes will be discussed, as well as general and specific methods for isolation, characterization and study. Enzyme kinetics, induction and repression, and isoenzyme systems will also be covered with emphasis on current findings.

BI 561 Electron Microscopy (2-3)3
[Permission of Instructor]

An introduction to the theory and operation of the transmission and scanning electron microscopes. Preparation of biological specimens for EM viewing and photography will be stressed. Applications in biology will be discussed.

CHEMISTRY

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The cirriculum includes elective credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in dveloping his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

CHEMISTRY PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA	131		
or			
MA	133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	126	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
PH	142	Physics	(3-1)3
PE	102	Physical Education	(0-2)1
		Total Hours	(13-6)15

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

CH	207	Inorganic Chemistry	(3-3)4
CH	221	Organic Chemistry	(3-4)4
MA	231		(4-0)4
or			or
MA	233	College Math III or Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
*PH	243	Physics	(3-1)3
		Total Hours	(15-8)17 or 16

*PH 247 Honors Physics may be substituted

Second Semester

CH	222	Organic Chemistry	(3-4)4
CH	232	Physical Chemistry	(3-3)4
MA	232		(4-0)4
or			or
MA	234	College Math IV or Calculus IV	(3-0)3
		General Elective	(3-0)3
		Total Hours	(13-7)15 or 14

JUNIOR YEAR

First Semester

CH	313	Analytical Chemistry I	(3-4)4
CH	333	Physical Chemistry	(3-3)4
LL	261	Elementary Technical German	(3-0)3
		Two General Electives	(6-0)6
			17

Second Semester

CH	314	Analytical Chemistry II	(3-4)4
CH	334	Advanced Inorganic Chemistry I	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		Chemistry Elective	3 or 4
		General Elective	(3-0)3
			16 or 17

SENIOR YEAR

First Semester

Chemistry Elective	3 or 4
One Technical Elective	3
Two General Electives	6
One Technical or General Elective	3
	15 or 16

Second Semester

Chemistry Elective	3 or 4
One Technical Elective	3
Two General Electives	6
One Technical or General Elective	3
	15 or 16

The technical electives in the junior and senior years must include Chemistry subjects which will provide a minimum of 65 contact hours of laboratory instruction. Recommended laboratory electives include CH 321, CH 342, CH 405 and 406, CH 407 and CH 408, CH 481 and CH 482, and BI 306. If undergraduate thesis is elected, both semesters must be taken.

A student electing Air Force ROTC in the junior and senior years may substitute a maximum of 6 credits of required general or technical electives by AS subjects. It is recommended that this substitution be made in the senior year.

CHEMISTRY COURSE DESCRIPTIONS

CH 121 **Chemistry** **(3-0)3**

Introduction to basic concepts of chemistry. Topics include chemical nomenclature, formulas and equations, chemical reactions and energy changes, gases, liquids, solids, changes in state, solutions, and chemical equilibrium.

CH 122 **Chemistry** **(3-0)3**
[CH 121]

A continuation of CH 121 with particular emphasis upon the applications of chemistry in engineering, industry, life, and the environment.

CH 123 **Chemistry Laboratory** **(0-3)1**

An experimental study of chemical principles and chemical transformations. Reactions of some important elements and compounds are examined and related to the periodic table. Considerable emphasis is placed on acquainting students with techniques, methods and instruments essential to quantitative chemical measurements. Topics include methods of chemical separation, reactions, organic synthesis, formula determination and absorption spectroscopy.

CH 124 **Chemistry Laboratory** **(0-3)1**
[CH 123]

A continuation of the experimentation of CH 123 including freezing point depression, metal activities, equilibrium, spectroscopy, reaction rates, pH, redox potentials, and formation of salts. Analytical chemistry is introduced with acid-base and oxidation-reduction titrations. Careful observation and logical deduction techniques are encouraged.

CH 126 **Chemistry** **(3-0)3**
[CH 121]

A continuation of CH 121 emphasizing concepts useful to those who will directly use chemistry in further education or careers. Topics include atomic and molecular structure, principles of thermodynamics, reaction rates, redox processes, acids and bases, and principles of organic chemistry.

CH 127 **Honors Chemistry** **(3-0)3**
[Permission of Instructor]

A course designed for capable students. Considerations of atomic and molecular structure and the periodic properties of the elements are developed from the classic experiments. The mole concept is applied in the study of stoichiometry and the gas laws. The rudiments of inorganic nomenclature are applied to selected ions and compounds.

CH 128 **Honors Chemistry** **(3-0)3**
[Permission of Instructor]

Physical states of matter and elementary thermodynamics are used to support study of solutions, chemical equilibrium, chemical kinetics, acids and bases, and selected special topics.

CH 129 **Chemistry** **(3-0)3**

An introductory chemistry course with emphasis placed on concepts and practices of chemistry as they relate to the individual, society, and industry. Topics covered are the metric system, atomic structure, radioactivity, acids and bases, and general classifications of the elements, compounds, and types of reactions.

CH 207 **Inorganic Chemistry** **(3-3)4**
[CH 122 or CH 126 or CH 128]

The chemical behavior, structures, methods of preparation, and nomenclature of the more important elements and their compounds. The laboratory illustrates basic principles used in the preparation and study of inorganic compounds.

CH 221 **Organic Chemistry** **(3-4)4**
[CH 122 or CH 126 or CH 128]

Kernel-electronic formulation, nomenclature and mechanism of reaction of the following classes of chemical species: monatomic, diatomic, multiatomic molecules and ions, alkanes, alkenes, alkynes, other non-aromatic hydrocarbons, alkyl halides, organometallics, alkanols, alkyl esters of inorganic acids, dialkyl ethers, alkanoic acids and derivatives. The laboratory work consists of practice in planning and carrying out reactions to form products isolable by distillation.

CH 222 **Organic Chemistry** **(3-4)4**
[CH 221]

Formulation, nomenclature, mechanism of reaction, and overall equations for property reactions of the following classes of compounds: aldehydes; ketones; amines; organosulfurs; carbonic acid derivatives; multihydroxyaldehydes and derivatives including stereochemistry; carbohydrates; arenes; aryl halides; arenesulfonic acids; nitroarenes; arylamines; phenols; quinones; aromatic aldehydes, ketones, alcohols and carboxylic acids; multicyclic aromatic hydrocarbons and derivatives; heterocyclics and alkaloids. The laboratory work consists of instruction and practice in planning and successfully carrying out reactions to form solid products isolable by crystallization.

CH 223 **Introductory Organic Chemistry I** **(3-0)3**
[Primarily for students not majoring in Chemistry]

Lectures in this course will include discussions of structures (with emphasis on molecular orbital theory and stereochemis-

try), classification by functionality, nomenclature, syntheses, and reactions and reaction mechanisms or organic compounds.

CH 224 Introductory Organic Chemistry II (3-0)3
[CH 223]

A continuation of the first semester subject (CH 223).

CH 225 Introductory Organic Chemistry Laboratory I (0-4)1

Laboratory work in this course is scheduled to accompany topic presentations in the lecture phase of the course (CH 223), and will be devoted to product separation and purification techniques, and methods of synthesis of industrially important organic compounds.

CH 226 Introductory Organic Chemistry Laboratory II (0-4)1
[CH 225]

A continuation of the first semester lab course (CH 225).

CH 232 Physical Chemistry (3-3)4
[MA 231 or MA 233]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 313 Analytical Chemistry I (3-4)4
[CH 122 or CH 126 or CH 128]

This course will focus on the evaluation of analytical data, aqueous and non-aqueous acid-base systems; oxidation reduction and complexation equilibria; solubility and precipitation, solvent extraction, ion-exchange and chromatographic methods. In the laboratory the student will perform experiments in gravimetric and volumetric methods of analysis.

CH 314 Analytical Chemistry II (3-4)4
[CH 313, CH 333]

The course will introduce the student to the modern instrumental methods of chemical analysis. The following techniques will be discussed: flame photometry; emission, atomic absorption, ultraviolet, infrared and nuclear magnetic resonance spectroscopy; potentiometry, electrolysis, coulometry, polarography, and amperometry; thermogravimetric and differential thermal analysis. Experiments emphasizing these techniques will be conducted by the student in the laboratory.

CH 321 Organic Chemistry Laboratory II (1-6)3
[CH 222]

A continuation of CH 222 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 333 **Physical Chemistry** **(3-3)4**
[CH 232]

Introduction to principles of statistical mechanics, kinetics, electrochemistry, and atomic and molecular structure.

CH 334 **Advanced Inorganic Chemistry I** **(3-0)3**
[CH 333]

A theoretical treatment of the structure of the atom and inorganic compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics, theories of the chemical bond, crystal field theory, ligand field theory, and inorganic stereochemistry.

CH 335 **Principles of Physical Chemistry** **(3-0)3**
[MA 231 or MA 233]

Similar to CH 232 but designed for students not majoring in Chemistry.

CH 336 **Principles of Physical Chemistry** **(3-0)3**
[CH 335]

A continuation of CH 335 emphasizing aspects of physical chemistry important to fields of specialization related to chemistry.

CH 337 **Principles of Physical Chemistry Laboratory** **(0-3)1**
[CH 335 prerequisite or corequisite]

Laboratory work designed to exemplify principles and applications covered in CH 335.

CH 338 **Principles of Physical Chemistry Laboratory** **(0-3)1**
[CH 336 prerequisite or corequisite]

Laboratory work designed to exemplify principles and applications covered in CH 336.

CH 342 **Organic Qualitative Analysis** **(1-6)3**
[CH 222]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403 **Introductory Physical Chemistry of Macromolecules** **(3-0)3**
[CH 222 or 224, CH 333 or 336]

An introduction to the physical chemistry of polymers, including molecular weight distributions and averages, polymer solutions, fractionation, methods of molecular weight determination, and structure and properties in the rubbery, glassy, and crystalline states.

CH 404 Introductory Organic Chemistry of Macromolecules (3-0)3

[CH 222 or 224, CH 333 or 336]

The organic chemistry of monomers and polymers including condensation and addition polymerization, copolymerization, mechanism of ionic and free radical polymerization, preparation of monomers and stereospecific polymers, naturally occurring and industrially important polymer.

CH 405 Polymer Laboratory I (0-4)1

[CH 222 or 224, CH 333 or 336]

An introductory laboratory in polymer science concerned with the characterization of polymers by solubility, viscosity and heat of polymerization, the kinetics of condensation polymerization, and the preparations of various polymers by means of the techniques of low temperature condensation, suspension and emulsion polymerization, the purification of polymers and the preparation of foams and inorganic polymers.

CH 406 Polymer Laboratory II (0-4)1

[CH 222 or 224, CH 333 or 336]

An introductory laboratory in polymer science concerned with the preparations of resins and elastomers, polymerization by anionic initiation and oxidative coupling, fractionation of polymers, kinetics of addition polymerization, chain transfer, copolymerization and reactivity ratios, thermogravimetric analysis and differential thermal analysis.

CH 407 Undergraduate Thesis (0-9)3

[Permission of Department Head and Instructor]

Open only to Seniors majoring in chemistry. Research in analytical, organic, inorganic, physical, and polymer chemistry.

CH 408 Undergraduate Thesis (0-9)3

A continuation of CH 407. Both semesters must be taken and not more than six credits may be used in meeting degree requirements. Letter grades are given in both semesters. A written thesis is required following the conventional form of introduction, literature survey, results and conclusions. One copy of the thesis must be filed with the department office.

CH 409 History of Chemistry (1-0)1

A seminar course devoted to the discussion of the historical development of chemical principles. Each student is required to present to the class a paper for discussion.

CH 413 Nuclear Magnetic Resonance and Electron Spin Resonance Spectroscopy (3-0)3

[CH 432]

An introduction to the essentials of nuclear and electron spin

resonance is presented to illustrate the scope and application of the method. May be taken for graduate credit.

CH 423 Advanced Organic Chemistry (3-0)3
[CH 222]

Extension of introductory organic chemistry for chemistry majors. Organic compounds and reactions are discussed in terms of reaction mechanisms, structure-reactivity and stereochemistry.

CH 424 Advanced Organic Chemistry (3-0)3
[CH 222]

Synthesis of organic molecules. Selected reagents and techniques are discussed with emphasis on the scope and limitations of these reactions. The reaction mechanisms are also discussed.

CH 431 Advanced Physical Chemistry I (3-0)3
[CH 333 or Equivalent]

Extension of introductory physical chemistry. Open to seniors and first year graduate students in Chemistry and related fields. Emphasis is placed on classical and statistical systems of chemical interest.

CH 432 Advanced Physical Chemistry II (3-0)3
[CH 431 or Equivalent]

Continuation of CH 431, with emphasis on quantum chemistry of atoms and molecules.

CH 434 Colloid Science and its Environmental Applications (3-0)3
[CH 333 or CH 336 or Equivalent]

An introduction to the fundamentals of colloid and interface science. Topics discussed include solid/gas, solid/liquid, and liquid/liquid interfaces; association colloids, emulsion suspensions, aerosols and foams. Additional topics include applications of colloid science to environmental problems, floculation and stability, adsorption and ion exchange, ultrafiltration, reverse osmosis, and electro-kinetic phenomena.

CH 445 Advanced Inorganic Chemistry II (3-0)3

A continuation of CH 334 with emphases on the chemical applications of group theory. Topics include the elements of group mathematics, the symmetry point groups, and the use of symmetry and group theoretical principles as applied to electronic structure, vibrational spectra, and ligand field theory.

CH 481 Radiochemistry (2-3)3
[Permission of Instructor]

An introduction to the fundamentals of radioactivity and radiochemistry. The laboratory work is directed to the detection

and measurement of radioactivity. Designed primarily for majors in chemistry and allied fields.

CH 482 Radiochemistry (2-3)3
[CH481]

A continuation of CH 481 with emphasis on the applications of chemical and nuclear principles and practices toward the preparation and separation of radionuclides. The laboratory experiments use such well-known techniques of separation as solvent extraction, ion-exchange, precipitation, coprecipitation and electrochemical displacement.

CH 484 Elements of Radiochemistry (2-3)3

Chemical principles are reviewed and their applications to radiochemistry are discussed. Such topics as separation procedures and chemical identification of nuclides, radiation chemistry, and study of fission products are included in the course.

CH 502 Color Science (2-3)3

An analytical course of the concepts and methods of absorption and reflectance spectrophotometry, and color measurement. Encompasses both theoretical and applied methods for determining qualitative and quantitative composition of colored substances in transparent and opaque materials such as liquids, paper, plastics, textiles, etc. Quantitative measurement of color, color difference, color matching and formulation by instrumental means based on the CIE and other trichromatic coordinate systems are studied. Computer usage and computer program developing problems are employed.

CH 513 Spectroscopy (3-0)3
[CH 431 and 432]

A presentation of molecular spectra and molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results.

CH 514 Advanced Analytical Chemistry (3-0)3
[CH 431 or equivalent]

An emphasis is placed on the determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions.

CH 515 Chemical Literature (1-0)1

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding, assembling and using such data.

CH 516 Advanced Laboratory Technique (1-3)2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of

organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 517 Glass Working (1-1)1

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 519 Environmental Chemistry (3-0)3
[CH 314 or Equivalent]

A study of the reactions involving atmospheric and aquatic pollutants. Included are such topics as the oxides of nitrogen, carbon, and sulfur, particulate matter in air, and equilibria occurring in natural waters. Approved "wet" and instrumental methods of analysis for pollutants of current interest are also presented.

CH 521 Physical Organic Chemistry (3-0)3

Modern and Classical Methodology in the study of organic reactions. Fast reactions, linear free energy relationships, tracer methods, instrumental techniques and other selected topics will be covered.

CH 523 Organic Reaction Mechanisms and Structures (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 Organic Synthesis (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate students only.

CH 526 Theory and Applications of Chromatography (3-0)3
[Permission of Instructor]

A treatment of the theory underlying chromatographic separations and processes. Included are such topics as gas-liquid, gas-solid, thin-layer, column and gel permeation chromatography. Applications of the various chromatographic methods are discussed.

CH 527 Stereochemistry (3-0)3

The fundamental concepts of optical and geometric isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds. Offered in alternate years.

CH 531 Statistical Thermodynamics (3-0)3
[CH 432 or equivalent]

Fundamentals of equilibrium statistical mechanics; classical and quantum statistics. Molecular theories of gases, crystals, and liquids, with emphasis on chemical aspects. Electrolyte and nonelectrolyte solutions, polymer and polyelectrolyte systems, chemical equilibria and reaction rate processes. Also, introduction to nonequilibrium statistical theories.

CH 534 Quantum Chemistry (3-0)3
[CH 431 or equivalent]

Principles and methods of quantum mechanics with special attention to chemical applications, such as electronic structure of atoms and molecules, vibration and rotation of molecules, and interaction of radiation with matter.

CH 535 Advanced Topics in Physical Chemistry (3-0)3
[Permission of instructor]

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 536 Advanced Topics in Physical Chemistry (3-0)3
[Permission of instructor]

Same as CH 535, with different topics.

CH 540 Chemical Kinetics (3-0)3
[CH 333 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 543 Modern Inorganic Chemistry I (3-0)3
[CH 333 or equivalent]

Similar to CH 334 but designed specifically for graduate students. Emphasis is placed on the theoretical-physical concepts of importance to inorganic chemists.

CH 544 Chemical Applications of Group Theory (3-0)3

A continuation of CH 543 with emphasis on the use of Group Theory as applied to ligand field theory, electronic spectra, and vibrational spectra.

CH 561 Advanced Organic Synthesis (3-0)3
[CH 523 and 524, or equivalent]

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids,

antibiotics. Theoretical implications of organic reactions are also discussed.

Offered in alternate years.

CH 563 Chemistry of Natural Products (3-0)3
[CH 568, CH 314 or Equivalent]

This course will cover the proof of structure of various types of natural products, approaches to the total synthesis of same and also the biosynthetic pathways.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy.

POLYMER SCIENCE COURSE DESCRIPTIONS

PS 503 Advanced Polymer Science I (3-0)3
[Permission of Instructor]

Introduction to chain statistics and thermodynamics of macromolecular solutions, methods of study of molecular weight and chain conformations, and the properties of polymers in bulk including viscoelasticity and crystallinity.

PS 504 Advanced Polymer Science II (3-0)3
[Permission of Instructor]

A study of the principles of condensation, free radical, ionic, coordination and ring-opening polymerization. The topics include the concepts of step-growth and chain-growth polymerization, the effect of polymerization technique on reaction kinetics and molecular weight and molecular weight distrubition, and the evaluation of reactivity ratios in copolymerization reactions.

PS 505 Polymer Preparation and Characterization I (0-4)1
[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the techniques used in the syntheses and characterization of macromolecules.

PS 506 Polymer Preparation and Characterization II (0-4)1
[Permission of Instructor]

An advanced laboratory in polymer science concerned with the instrumental study of macromolecules by utilization of osmometry, light scattering, gel permeation chromatography, vapor pressure osmometry, infrared spectroscopy, thermogravimetric analysis and differential thermal analysis.

PS 511 Biopolymers (2-0)2
[Permission of Instructor]

Conformation and configuration of vinyl polymers and polypeptides. Helix-coil transitions in proteins and polypeptides. Biological specificity and macromolecular structure. Synthesis of stereoregular polypeptides. Structure and physical properties of nucleic acids. Relations of synthetic polymers to naturally occurring polymers.

PS 512 Bulk Properties of Polymers (2-0)2
[Permission of Instructor]

Structure and properties of bulk polymers in the glassy, rubbery, and crystalline states. Topics covered include chain statistics, rubber elasticity, glass transition, segmental motion and viscoelasticity.

PS 549 Physical Chemistry of Macromolecules I (2-0)2
[CH 503 or equivalent]

Physical chemistry of polymers, including structure and conformation, chain statistics, molecular weight distributions and averages, polymerization kinetics and classical and statistical thermodynamics of polymer solutions.

PS 550 Physical Chemistry of Macromolecules II (2-0)2
[CH 549 or equivalent]

Optical and hydrodynamic properties of polymer solutions. Methods of determination of structural parameters, including light scattering, viscometry, and other techniques.

PS 553 Organic Chemistry of Macromolecules (2-0)2
[PS 503, 504]

An advanced study in polymer science concerned with the syntheses of macromolecules and their mechanisms of formation.

MATHEMATICS

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics — algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields of teaching and industry.

MATHEMATICS PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA	131		
or			
MA	133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	122	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
*PH	142	Physics	(3-1)3
PE	102	Physical Education	(0-2)1
		Total Hours	(13-6)15

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

MA	231		(4-0)4
or			or
MA	233	College Math III or Calculus III	(3-0)3
MA	211	Fundamental Concepts in Mathematics	(3-0)3
		Language Elective	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total Hours	(16-0)16 or (15-0)15

*LL and SS courses only

Second Semester

MA	232		(4-0)4
or			or
MA	234	College Math IV or Calculus IV	(3-0)3
MA	221	Linear Algebra	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
		Language Elective	(3-0)3
		General or Technical Elective	(3-0)3
		General Elective*	(3-0)3
		Total Hours	(18-0)18 or (17-0)17

*LL and SS courses only

JUNIOR YEAR

First Semester

MA	301	Applied Mathematics I	(3-0)3
MA	305	Introduction to Real Analysis I	(3-0)3
		Mathematics Elective*	(3-0)3
		Elective	(3-0)3
		General Elective**	(3-0)3
		Total Hours	(15-0)15

*To be approved by the Department
**LL and SS courses only

Second Semester

MA	302	Applied Mathematics II	(3-0)3
MA	306	Introduction to Real Analysis II	(3-0)3
		Mathematics Elective*	(3-0)3
		Elective	(3-0)3
		General Elective**	(3-0)3
		Total hours	(15-0)15

*To be approved by the Department
**LL and SS courses only

SENIOR YEAR

First Semester

MA	411	Complex Variables I	(3-0)3
MA	421	Modern Algebra I	(3-0)3
		Mathematics Elective*	(3-0)3
		Elective	(3-0)3
		General or Technical Elective**	(3-0)3
		Total hours	(15-0)15

*To be approved by the Department
**ROTC students may substitute AS 401

Second Semester

		Mathematics Elective*	(3-0)3
		Mathematics Elective*	(3-0)3
		Mathematics Elective*	(3-0)3
		Elective	(3-0)3
		General or Technical Elective**	(3-0)3
		Total hours	(15-0)15

*To be approved by the Department
**ROTC students may substitute AS 402

MATHEMATICS COURSE DESCRIPTIONS

MA 101 — Mathematical Analysis I — (3-0)3

Review of algebra, factoring, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, mathematical induction, progressions, logarithms, mathematics of investment, permutations and combinations.

MA 102 — Mathematical Analysis II — (3-0)3

[MA 101]

Calculus with applications in economics and management science: straight line, limits, tangent lines, derivatives, max-min problems, implicit differentiation, business applications to derivatives, integral calculus with applications to management science.

MA 131 — College Mathematics I — (4-0)4

Functions and graphs, linear equations, trigonometric functions, trigonometric identities, quadratic equations, logarithms, complex numbers, solution of triangles, binomial theorem, and the conics.

MA 132 — College Mathematics II — (4-0)4

Limits, the differentiation of algebraic and transcendental functions, rates, applied maxima and minima, definite integrals, areas, hyperbolic functions, L'Hopital's rule and polar equations.

MA 133 — Calculus I — (4-0)4

Functions and graphs, equations of straight lines, the conics, the differentiation of algebraic functions together with applications involving velocity and acceleration, maxima and minima, related rates and approximations, definition of integrals and area under curve.

MA 134 — Calculus II — (4-0)4

Applications of integration including volumes arc length and areas, the differentiation of trigonometric and exponential functions, methods of integration including parts, partial fractions and trigonometric substitution, parametric equations, polar coordinates and hyperbolic functions.

MA 201 — Mathematical Analysis III — (3-0)3

[MA 102]

Linear Programming with graphs and ordinary algebra. Matrix algebra leading to the simplex solution of linear programming problems.

MA 207 — Mathematical Techniques of Physics I — (4-0)4

[For Physics Majors Only]

Hyperbolic functions, polar coordinates, vectors and para-

metric equations, solid geometry and vectors, partial differentiation, multiple integrals.

MA 208 Mathematical Techniques of Physics II (4-0)4
[MA 207]
[For Physics Majors Only]

Differential equations: first order, linear and power series solution. Vector calculus, gradient, divergence and curl. Integral transform theorems.

MA 211 Fundamental Concepts in Mathematics (3-0)3

The logic of mathematical operations. Quantified statements. Methods of proof. Disproofs. Elementary set theory. Ordered pairs and functions. Axiomatic introduction to the real number system including the Dedekind axiom and mathematical induction.

MA 221 Linear Algebra (3-0)3
[MA 211]

Vectors in R^n, vector spaces, matrices, linear mappings, matrix associated with a linear map, eigenvalues and eigenvectors, diagonalization of matrices, applications in R^n.

MA 231 College Mathematics III (4-0)4

Parametric equations, methods of integration including parts, trigonometric substitution and partial fractions, areas, volumes, length of curve, first and second moments, vector products and three dimensional surfaces.

MA 232 College Mathematics IV (4-0)4

Partial derivatives, multiple integrals, infinite series with tests of convergence, first and second order differential equations with applications.

MA 233 Calculus III (3-0)3

Vector algebra including dot and cross products, equation of lines and planes, partial derivatives, chain rule, implicit functions, and multiple integrals with applications.

MA 234 Calculus IV (3-0)3

Indeterminate forms, series, tests for convergence, Taylor series, first and second order differential equations with applications.

MA 242 Electronic Data Processing (3-0)3

Background to the digital computer covering topics such as: input-output, storage, calculation principles, addressing, computer arithmetic, instruction codes and numbering systems. Computer programming in the business oriented computer language COBOL will be taught on the Institute's CDC 3100 computer.

MA 301 **Applied Mathematics I** **(3-0)3**

[MA 232 or MA 234]

Vector Analysis, review of vector algebra, vector calculus, divergence theorem, Green's Theorem and Stokes' Theorem. Laplace Transforms.

MA 302 **Applied Mathematics II** **(3-0)3**

[MA 301]

Series solution of ordinary differential equations, Bessel functions, Legendre functions. Ordinary differential equations boundary value problems, Fourier series and integrals. Partial differential equations of physics and engineering, separation of variables.

MA 305 **Introduction to Real Analysis I** **(3-0)3**

[MA 211]

Equivalence and countability. Sets and sequences of real numbers. Metric spaces.

MA 306 **Introduction to Real Analysis II** **(3-0)3**

[MA 305]

Limits and continuity in metric spaces. The Riemann integral and the derivative.

MA 311 **Applications of Linear Algebra** **(3-0)3**

[Ma 221]

Bilinear forms, Hamilton-Caley Theorem, the Spectral Theorem, Jordan normal form, matrix calculus. Applications to differential equations, Fourier series.

MA 315 **Complex Variables for Engineers** **(3-0)3**

[MA 232 or MA 234]

Complex variables with emphasis on Electrical Engineering applications. Analytic functions, Cauchy-Riemann conditions. Line integrals, Cauchy's integral formula and residues. Singularities. Taylor and Laurent series.

MA 334 **Projective Geometry** **(3-0)3**

[MA 211]

Foundations of geometry, homogenous coordinates, projective spaces, conics, linear transformations and surfaces.

MA 335 **Differential Geometry** **(3-0)3**

[MA 211]

Applications of analysis to the study of space curves and surfaces.

MA 361 **Digital Computer Programming** **(2-0)2**

Programming principles of the FORTRAN language including

input-output, arithmetic, control and specification statements, subroutines and advanced techniques. Students will process several problems on the Institute's computer.

MA 362 Numerical Analysis (3-0)3
[MA 231 or MA 233 and MA 361]

Theory and application of numerical techniques including error analysis, linear, non-linear and differential equations, matrices, interpolation, numerical integration and curve fitting. Computer solutions are emphasized.

MA 363 Introduction to Computing (3-0)3

Types of computers and their operation. Characteristics, storage and calculation principles. Addressing schemes. Computer arithmetic and logic, numbering systems, instruction codes, input-output organization and devices.

MA 365 Business Computer Programming (3-0)3
[MA 242]

Programming principles of COBOL, the **CO**mmon **B**usiness **O**riented **L**anguage; identification, environment, data, and procedures divisions, introduction to compilation procedures. Students will process several business problems on the Institute's CDC 3100 Computer.

MA 371 Number Theory (3-0)3
[MA 211]

Congruences and residue classes, quadratic residues. Diophantine equations, number theoretic functions, distribution of primes.

MA 381 Operations Research I (3-0)3
[MA 132 or MA 134 or MA 102]

The use of decision models in industrial systems. Quantitative approach to the industrial alternative. Fundamentals of probability and statistics, PERT techniques, methods of optimization using calculus, inventory control models and queuing models.

MA 382 Operations Research II (3-0)3
[MA 381]

A continuation of MA 381. Topics include: linear programming, transportation models, nonlinear programming, dynamic programming, games and strategies. Markov analysis, and simulation techniques.

MA 383 Introduction to Statistics (3-0)3

Sets and probability laws, random variables, mathematical expectation, measure of central tendency and variance. Study of

discrete and continuous probability distribution, sampling theory, tests of hypothesis. Regression and correlation.

MA 401 — Applied Mathematics III — (3-0)3
[MA 302]

Applications of mathematical methods to the solution of problems in the various scientific and engineering disciplines.

MA 407 — Introduction to Probability Theory — (3-0)3
[MA 232 or MA 234]

Probability functions and densities, expectations. Moments of probability distributions. Central limit theorem.

MA 408 — Introduction to Mathematical Statistics — (3-0)3
[MA 407]

Sampling, decision theory, estimation, hypothesis testing, regression and correlation.

MA 411 — Complex Variables I — (3-0)3
[MA 232 or MA 234]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals, Cauchy integral formula; power series and residues and poles.

MA 412 — Complex Variables II — (3-0)3
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 414 — Mathematical Methods in Engineering Management — (3-0)3

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

MA 421 — Modern Algebra I — (3-0)3
[MA 221]

Elementary group theory; groups, cosets, normal subgroups, quotient groups, isomorphisms, homomorphisms, series of groups, the Sylow Theorems, free groups and homology groups.

MA 422 — Modern Algebra II — (3-0)3
[MA 421]

Elementary ring and field theory, quotient rings and ideals, homomorphisms of rings, rings of polynomials, algebraic extensions, automorphisms of fields, separable extensions. Galois Theory. Introduction to categories and functors.

MA 431 **Topology I** **(3-0)3**
[MA 211]

Cardinality, partially ordered sets and Zorn's lemma, topology of the line and plane, topological spaces, continuity and topological equivalence.

MA 432 **Topology II** **(3-0)3**
[MA 431]

Metric and normed spaces, compactness, connectedness, product spaces, function spaces, fundamental group.

MA 433 **Matrix Theory** **(3-0)3**
[MA 232 or MA 234]

Algebra of vectors, matrices and determinants. Linear transformations and vector spaces. Characteristic values and diagonal forms. Calculus of matrices, matric polynomials. Matric differential equations. Applications.

MA 442 **Boundary Value Problems** **(3-0)3**
[MA 232 or MA 234]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics and engineering, and boundary value problems.

MA 445 **Operational Calculus** **(3-0)3**
[MA 232 or MA 234]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation and integration. Applications in the analysis of vibrations, deflections, and electric circuits, problems in partial differential equations, and Fourier transforms.

MA 452 **Applications of Numerical Analysis** **(3-0)3**
[MA 232 or MA 234 and MA 361]

Iterative solutions of transcendental equations. Rapidity of convergence and error estimates. Numerical differentiation and integration. Extrapolation and Romberg quadrature, interpolation, numerical solution of ordinary differential equations. Predictor-corrector formulas. Partial differential equations. Applications, computer solutions.

MA 471 **Optimization and Mathematical Programming I** **(3-0)3**
[MA 232 or MA 234]

Linear programming, simplex method, transportation problems, applications. Convex programming, Chebyshev approximation.

MA 472 — Optimization and Mathematical Programming II — (3-0)3

[MA 471]

Convex programming, Kuhn-Tucker Theorem; Geometric programming, Dual Function, Optimum design problems; Dynamic Programming, Calculus of Variations.

MA 475 — Mathematical Logic — (3-0)3

[MA 211]

Propositional and statement logic. A rigorous development of the science of deductive logic with an emphasis on the nature of the logical structure underlying mathematical systems.

MA 497 — Foundations of Mathematics — (3-0)3

[Senior Standing]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 498 — Mathematics Seminar — (3-0)3

[Senior Standing]

Student reading, writing and criticism, topics from current literature, and review of some important elements of the undergraduate work.

MA 501 — Advanced Real Analysis I — (3-0)3

Introduction to the real and complex number systems, elements of set theory including the Bolzano Weierstrass and Heine-Borel theorems, numerical sequences and series, continuity.

MA 502 — Advanced Real Analysis II — (3-0)3

Differentiation, Riemann integration, sequences and series of functions, and functions of several variables.

MA 511 — Complex Analysis I — (3-0)3

Complex numbers and their geometric representation, linear functions, sets and sequences and power series, analytic functions and conformal mappings, elementary functions, complex integration and integral theorems.

MA 512 — Complex Analysis II — (3-0)3

Series and the expansion of analytic functions in series, singularities, single valued functions, entire functions, meromorphic functions, periodic functions.

MA 537 — Tensor Analysis I — (3-0)3

Tensor algebra in affine coordinates in n-dimensional space, algebra and calculus of covariant and contravariant tensors and tensor densities, covariant differentiation and parallel displacement, curvature tensors.

MA 538 **Tensor Analysis II** **(3-0)3**

Applications of tensor analysis to differential geometry of Riemannian spaces, analytical dynamics, mechanics of continuous media and theory of relativity.

MA 545 **Partial Differential Equations I** **(3-0)3**

First and second order partial differential equations, transformation theory in the plane and space. Applications to mathematical physics.

MA 546 **Partial Differential Equations II** **(3-0)3**

Classification and methods of solution. Properties of solutions of equations with initial and boundary conditions. Existence and uniqueness theorems.

MA 547 **Integral Equations** **(3-0)3**

Exact, iterative and numerical techniques for the solution of linear Volterra and Fredholm integral equations; theorems for general operators; symmetric kernels, orthogonal system of functions and the Hilbert-Schmidt theorem; relation of integral equations to differential equations; applications of the Rayleigh-Ritz, Galerkin, and variation-iteration techniques to the solutions of eigenvalue-eigenfunction problems occurring in Mathematical Physics and Engineering.

MA 551 **Calculus of Variations** **(3-0)3**

The first variational problem; necessary conditions; Euler's equation. Generalization to several dependent and independent variables. Constraints and Lagrange multipliers. Applications to dynamics and elasticity. Hamilton equations. Sturm-Liouville problems, direct methods; Rayleigh-Ritz method.

MA 563 **Advanced Numerical Analysis I** **(3-0)3**

Iterative solutions of non-linear equations. Interpolation, numerical differentiation and integration. Summation of series. Least squares approximation, orthogonal polynomials. Chebyshev approximation. Ill-conditioning. Computer applications.

MA 564 **Advanced Numerical Analysis II** **(3-0)3**

Systems of linear equations. Gauss eliminations, LU decompositions. Wilkinson round-off error analysis. Scaling and condition number. Iterative methods. Application to elliptic partial differential equations. Applications to structural analysis. Computer solutions.

MA 584 **Analysis of Random Processes** **(3-0)3**

Axiomatic definition of Probability. Combined Experiments, Bernoulii Trials, Asymptotic Theorems, Bayes Theorem. The concepts of both discrete and continuous random variables, and functions of one or more random variables. The use of contin-

uous probability density functions to describe both discrete and continuous phenomena. Expected value, moments, characteristic functions, mean square estimation. Sequences of continuous random variables, convergence concepts, law of large numbers, Central Limit Theorem.

MA 587 Probability and Statistics (3-0)3

Probability: Develops probability tools required for statistical theory: probability distributions, random variables, moment generating functions, distribution theory and limit theorems.

MA 588 Probability and Statistics (3-0)3

Statistics: Sample moments and their functions, order statistics, significance tests, estimation theory, theories of hypotheses testing and decision making under uncertainty.

METEOROLOGY

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of weather for the general public to the analysis of the influence of weather and climate on public health and on particular operations in agriculture, engineering, industry and commerce and national defense.

Meteorologists are employed by the agencies of The National Oceanic and Atmospheric Administration, especially the National Weather Service, and of the Department of Defense as well as by the agencies of state and local governments, commercial aviation companies, and private consulting firms.

Research in meteorology and climatology is conducted by the agencies of the U. S. Government, universities, and industrial research companies. Graduate training is essential for advancement in this field and most employers provide opportunities for capable individuals to acquire this training.

The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

Meteorology Program

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA	131		
or			
MA	133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	122	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
*PH	144	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

MA	231		(4-0)4
or			or
MA	233	College Math III or Calculus III	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
MY	211	Elementary Meteorology	(3-0)3
PH	245	Physics	(4-2)4
		General Elective	(3-0)3
		Total Hours	(16-2)16 or (15-2)15

Second Semester

MA	232		(4-0)4
or			or
MA	234	College Math IV or Calculus IV	(3-0)3
MA	383	Introduction to Statistics	(3-0)3
MY	212	Elementary Meteorology	(3-0)3
PH	246	Physics	(4-2)4
		General Elective	(3-0)3
		Total Hours	(17-2)17 or (16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
MY	301	Atmospheric Dynamics	(3-0)3
MY	308	Synoptic Meteorology	(2-3)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total credit hours	(14-3)15

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
MY	302	Atmospheric Dynamics	(3-0)3
MY	313	Physical Climatology	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total credit hours	(15-0)15

SENIOR YEAR

First Semester

MY	403	Physical Meteorology	(3-0)3
MY	415	Advanced Atmospheric Dynamics	(3-0)3
MY	421	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	(3-0)3
		Total credit hours	(13-6)15

*ROTC students may elect AS 401.

Second Semester

MY	413	Oceanography	(3-0)3
MY	416	Advanced Atmospheric Dynamics	(3-0)3
MY	422	Analysis and Forecasting	(1-6)3
		General Elective*	(3-0)3
		Technical Elective	(3-0)3
		Total credit hours	(13-6)15

*ROTC students may elect AS 402.

METEOROLOGY COURSE DESCRIPTIONS

MY 211 — Elementary Meteorology — (3-0)3

[MA 104, PH 102]

Synoptic and mean spatial variations of pressure, temperature and velocity. Cyclones, anticyclones, fronts waves and jet streams. Elements of atmospheric thermodynamics and hydrodynamics; the equation of state, first law of thermodynamics, hypsometric equation, stability of hydrostatic equilibrium, thermal circulation, geostrophic and gradient motion, thermal wind.

MY 212 — Elementary Meteorology — (3-0)3

[MY 211]

Atmospheric and solar radiation. Atmospheric heat budget. Distribution and causes of fog, clouds, precipitation, thunderstorms and tornados. Elements of general circulation theory and tropical meteorology.

MY 301 — Atmospheric Dynamics — (3-0)3

[MY 211]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium and its stability. Convection theory. The equations governing large-scale frictionless motion in the atmosphere. Steady state motion.

MY 302 — Atmospheric Dynamics — (3-0)3

[MY 301]

Unsteady motion: development of thermal circulations: barotropic and baroclinic conditions, circulation, vorticity and divergence; mechanism of pressure change; Sutcliffe development and elements of numerical weather prediction.

MY 307 **Tropical Meteorology** **(3-0)3**
[MY 212]

An introduction to tropical meteorology. Distribution of temperature, water vapor and velocity. Observations from aircraft, satellites and radar. Analysis of tropical data. Air sea interaction; convection and clouds. The trade wind region and intertropical convergence zone. Easterly waves and tropical storms.

MY 308 **Synoptic Meteorology** **(2-3)3**
[MY 212]

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network.

MY 313 **Physical Climatology** **(3-0)3**
[MY 212]

Measurements and observations. Statistical methods. Atmospheric processes determining the climate; solar and terrestrial radiation, elevation and thermal properties of surfaces, atmospheric circulations and interactions between the atmosphere and land or sea surfaces, hydrological cycle.

MY 403 **Physical Meteorology** **(3-0)3**
[MY 302]

Solar and terrestrial radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; radiative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion.

MY 413 **Oceanography** **(3-0)3**
[MY 302]

Physical properties of sea water. Distribution of pressure, temperature and salinity. Heat budget. Theories of wind-driven and thermal circulations. Transfer processes. Waves and tides. General circulation theory.

MY 415 **Advanced Atmospheric Dynamics** **(3-0)3**
[MY 302]

Atmospheric discontinuities. Viscosity, turbulence and energy dissipation. Perturbation theory of wave motions. Numerical weather prediction techniques and models.

MY 416 Advanced Atmospheric Dynamics (3-0)3
[MY 415]

Stability of atmospheric circulations. General circulation theory and models. Thermal convection.

MY 421 Analysis and Forecasting (1-6)3
[MY 302, MY 308]

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting.

MY 422 Analysis and Forecasting (1-6)3
[MY 421]

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures.

MY 425 Statistical Methods in Meteorology (3-0)3
[MY 302]

Frequency distributions and their properties. Sampling theory and techniques. Relationships between variables. Analysis of time series and of spatial variation. Statistical forecasting and forecast verification. Factor analysis and experimental design.

MY 430 Atmospheric Diffusion (3-0)3
[Permission of Instructor]

Study of the meteorological processes that affect the diffusion and removal of atmospheric pollutants: theories of diffusion and their application to the calculation of concentrations; the effects of buildings and topography on atmospheric diffusion; meteorological factors involved in the design and location of stacks.

MY 441 Research Project (0-9)3

An individual or team research project carried out by qualified seniors under supervision of a faculty member.

PHYSICS AND APPLIED PHYSICS

Physics is that discipline which deals with the most fundamental aspects of nature. Its objective is the understanding of all natural phenomena in terms of a few fundamental concepts and relationships, and, as such, forms the basis for the development of all natural sciences. In a broad sense, some training in physics is essential for all who wish to understand the modern world and its technological evolution.

The basic undergraduate program in physics (Sequence I) offers a broad training in both experimental and theoretical physics. It is designed so that its graduates should be well equipped to build a career in industry or the teaching profession, or to enter graduate school for more advanced professional training. Students planning to major in physics should have a high level of competence in mathematics.

The student may also choose to pursue the Applied Physics sequence designated below (Sequence II). This sequence is designed to stress the applied nature of physics in science and technology. In addition to the required core curriculum listed, the student should also choose another field (in consultation with his advisor) in which he may effectively utilize his AP training. Examples of such supplementary fields are biology, chemistry, education, and the various engineering disciplines. It is hoped that this procedure would give the student maximum flexibility and freedom in matching his academic requirements with his own individual interests.

Students who have completed this sequence are well qualified to pursue careers in industry or government, working in research and development, or to continue graduate studies in any of the many applied physics disciplines. The interdisciplinary nature of the AP sequence should also afford the student a greater opportunity in realizing his career potentials.

PHYSICS AND APPLIED PHYSICS PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA	131		
or			
MA	133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	126	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
*PH	144	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

Sequence I

SOPHOMORE YEAR

First Semester

MA	207	Mathematics	(4-0)4
PH	247	Physics	(4-0)4
PH	293	Experimental Physics	(3-6)5
		Elective	(3-0)3
			(14-6)16

Second Semester

MA	208	Mathematics	(4-0)4
PH	248	Modern Physics	(4-0)4
PH	238	Optics and Waves	(2-0)2
PH	294	Experimental Physics	(1-6)3
		Elective	(3-0)3
			(14-6)16

JUNIOR YEAR

First Semester

PH	313	Mechanics	(4-0)4
PH	335	Quantum Mechanics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	393	Intermediate Laboratory	(0-6)2
		Elective	(3-0)3
			(13-6)15

Second Semester

PH	308	Mathematical Techniques of Physics	(4-0)4
PH	336	Quantum Mechanics	(3-0)3
PH	354	Electromagnetic Theory	(3-0)3
PH	394	Intermediate Laboratory	(0-6)2
		Elective	3
			(13-6)15

SENIOR YEAR

First Semester

PH	421	Statistical Thermodynamics	(4-0)4
PH	461	Nuclear Physics	(3-0)3
		3 Electives	9
			(16-0)16

Second Semester

PH	472	Solid State Physics	(3-0)3
		4 Electives	12
			(15-0)15

Electives may be either general of technical and may be chosen from among all of the courses offered by the Institute subject to the following conditions:

1. All electives must be approved by the student's advisor.
2. At least two electives must be in some foreign language, usually French, German or Russian, both electives being in the same foreign language.
3. At least two electives must be in the social sciences.
4. At least two electives must be general electives other than English I and English II (LL111 and LL112), required of all freshmen, and those general electives satisfying conditions 2 and 3.

Sequence II

SOPHOMORE YEAR

First Semester

MA	207	Mathematics	(4-0)4
PH	243	Physics	(4-0)3
PH	293	Experimental Physics	(3-6)5
		1 Elective	(3-0)3

Second Semester

MA	208	Mathematics	(4-0)4
PH	246	Physics	(4-0)3
PH	294	Experimental Physics	(1-6)3
		2 Electives	6
			(14-6)15

Second Semester

MA	208	Mathematics	(4-0)4
PH	246	Physics	(4-0)3
PH	294	Experimental Physics	(1-6)3
		2 Electives	6
			(15-6)16

JUNIOR YEAR

First Semester

AP	311	Applied Mechanics	(4-0)4
AP	335	Applied Modern Physics I	(3-0)3
PH	393	Intermediate Laboratory	(0-6)2
		2 Electives	6
			(13-6)15

Second Semester

AP	354	Applied Electromagnetism	(4-0)4
AP	336	Applied Modern Physics II	(3-0)3
PH	394	Intermediate Laboratory	(0-6)2
		2 Electives	6
			(13-6)15

SENIOR YEAR

First Semester

PH	421	Statistical Thermodynamics*	(4-0)4
NU	497	Computer Programming and Applications	(3-2)3
		3 Electives	9
			(15-2)16

Second Semester

		5 Electives	15
			(15-0)15

*This course may be replaced with another equivalent thermodynamics course offered by the Institute.

Technical electives, and general electives may be chosen from the courses offered by the Institute. The selection of electives is, however, subject to the following rules;

a. A nominal figure of 18 hours in the supplementary field is recommended.

b. If the supplementary field is not offered at LTI the student may arrange to take it at another accredited institution.†

c. No less than six courses and no more than ten may be chosen in the general electives category. (These courses are in addition to the Freshman English courses LL 111, and LL 112.)

d. At least two courses must be in language and literature, and two courses in the social sciences.

†For instance, a student planning to teach physics in high school may take the necessary education courses at Lowell State College.

PHYSICS AND APPLIED PHYSICS COURSE DESCRIPTIONS

PH 141 — Physics — (3-1)3

Units, vectors, force, rectilinear motion, Newton's laws of motion, applications of Newton's laws, friction, gravitation, two dimensional motion, projectiles, work, energy, power, potential energy (gravitational, Hooke's law)

PH 142 — Physics — (3-1)3

[PH 141]

Collisions, impulse, momentum, rotational motion, torque, angular momentum, simple harmonic motion; waves, standing waves, Doppler effect; geometrical optics, interference, diffraction; temperature, thermometers, ideal gas, heat, heat capacity, change of state, first and second laws of thermodynamics.

PH 144 — Physics — (4-1)4

[PH 141, MA 131]

Collisions, impulse, momentum, rotational motion, torque, angular momentum, simple harmonic motion; waves, standing waves, Doppler effect; geometrical optics, interference, diffraction; temperature, thermometers, ideal gas, heat, heat capacity, change of state, first and second laws of thermodynamics.

PH 147 — Honors Physics — (4-1)4

Introductory physics at a more challenging level, commencing with elementary mechanics: fundamental units and dimensions; vector treatment of forces and velocities; statics; equilibrium; kinematics of uniform and accelerated linear motion in one and two dimensions; Newton's laws of motion; friction; relativistic motion and frames of reference; dynamics — impulse, momentum, work, energy and power, conservation and invariance principles; motion of interacting systems; rotational motion-kinematics and dynamics; rotational angular momentum and energy; radial and tangential forces and accelerations; motion of gyroscopes and planets, laws of planetary motion.

PH 148 — Honors Physics — (4-1)4

[PH 147 or equivalent]

Gravitation; elasticity; fluid mechanics; simple harmonic motion; wave motion. Temperature and heat; ideal gas behavior; kinetic theory; thermal properties of matter; thermodynamics and statistical mechanics; radiation and quantum concepts.

PH 149 — Physics — (3-0)3

[For Business and Industrial Technology majors only]

An introduction to the topics of physics including: Forces, work and energy, motion, conservation laws, electricity, magnetism and waves.

PH 209 **Physics** **(4-0)4**

[PH 144, MA 132]

[For physics majors only]

Electorstatics: electric charge, Coulomb's law, electric field, Gauss' law, electric potential, capacitance, and dielectrics; electrodynamics: electric current, resistance, Ohm's law, resistivity, electromotive force, d-c circuits, magnetic field, magnetic dipole moment, Biot-Savart law, Ampere's law, Faraday's law, inductance, and Maxwell's equations.

PH 210 **Modern Physics** **(4-0)4**

[PH 209]

Special theory of relativity: Galilean transformation, nature and propagation of light, Einstein's postulates and assumptions, Lorentz transformation, simultaneity, time dilation, space contraction, velocity transformation, four vectors, proper time, Newton's second law of motion, conservation laws, center of mass, and collision problems. The electron: Millikan's experiment. Quantum nature of light: The Compton effect and the photoelectric effect. Matter waves: Davisson-Germer experiiments. Wave-particle duality and the Uncertainty Principle.

PH 238 **Optics and Waves** **(4-0)4**

[PH 209]

Waves: general representation, superposition, interference, standing waves, beats, and Doppler effect; acoustic waves; optics: nature of light, law of reflection, law of refraction, Huyghens' principle, mirrors, thin lenses, interference, Fraunhofer diffraction, multiple slits, diffraction grating, polarization, speed of light, electromagnetic waves.

PH 243 **Physics** **(3-1)3**

[PH 144, MA 132]

Electric charge, Coulomb's law, electric field, electric potential; D. C. current, Ohm's law, Joule effect; magnetic effects of charged particles and electric currents, Faraday's law, Lenz's law, examples; quantum theory: photoelectric effect, Compton effect, wave-particle duality, de Broglie waves, Davisson-Germer experiment, Bohr atom, atomic spectra.

PH 245 **Physics** **(4-1)4**

[PH 144, MA 132]

Electric charge, Coulomb's law, electric field, Gauss' law, electric potential, capacitance; D. C. current, Ohm's law, Joule effect, electromotive force, Kirchhoff's rules, simple D. C. Circuits; magnetic field, current loops, Ampere's law, Faraday's law, electromagnetic induction; quantum theory: photoelectric effect, Compton effect, wave-particle duality, de Broglie waves, Davisson-Germer experiment, Bohr atom, atomic spectra, nuclear structure.

PH 246 Special Topics in Physics (4-1)4

Special topics from the various branches of classical and modern physics, such as hydrodynamics, kinetic theory, relativity, and quantum mechanics.

PH 247 Honors Physics (4-1)4
[PH 142, 144 or 148, MA 134]

Elements of electricity and magnetism — electrostatics, Coulomb's law, electric fields, Gauss' law and flux considerations, potential, D. C. circuitry, dielectrics; magnetic fields and effects; magnetic properties of materials, A. C. circuitry; electromagnetic theory, Maxwell's equations.

PH 248 Honors Physics (4-1)4
[PH 247 or equivalent]

Wave behavior and interference; diffraction; acoustics and optics; polarization; quantum phenomena; theory of atoms and molecules; atomic nuclei; high-energy and particle physics; current developments in pure and applied physics.

PH 293-294 Experimental Physics (3-6)5-(1-6)3
[PH 144]

A course in experimental methods, with related theoretical material. Experiments principally in electrical measurements, along with a number in optics, heat, mechanics, and atomic physics. Lectures in laboratory techniques and practices, elementary theory of errors, and basic d-c and a-c circuit theory. Laboratory and theory are integrated.

PH 308 Mathematical Techniques of Physics (4-0)4
[MA 208]

Complex numbers, elementary functions; analytic functions, line integrals, Cauchy's formulae, residue theorem; partial differential equations of physics; separation of variables, eigenvalue problems, Fourier series, Fourier transforms.

PH 313 Mechanics (4-0)4
[MA 208]

Kinematics of a single particle, analysis of Newton's laws of motion, mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, the linear oscillator, forced oscillations and resonance, central force motion, kinematics and elastic collisions in two particle systems, mechanics of systems of particles, generalized coordinates, Lagrange's equations, the Hamiltonian function.

PH 335 Quantum Mechanics (3-0)3
[PH 210]

deBroglie waves, the Schroedinger equation, wave functions, wave packets, Heisenberg uncertainty principle, expectation values, particle in a box, the simple harmonic oscillator, free particles, step barrier, barrier penetration, square well potential.

PH 336 Quantum Mechanics (3-0)3
[PH 335]

The three dimensional Schroedinger equation, the deuteron nucleus, angular momentum, spin, the hydrogen atom, spin-orbit interaction, Zeeman effect, Pauli exclusion principle, atomic structure, spectroscopic nomenclature, and molecular structure.

PH 353 Electromagnetic Theory (3-0)3
[MA 208, PH 209]

The theory of electromagnetic fields using vector analysis and Maxwell's equations: static electric and magnetic fields in conductors and dielectrics, scalar and vector potentials, solutions to Laplace's equation, image charge problems, and energy density problems.

PH 354 Electromagnetic Theory (3-0)3
[PH 353]

Time-varying electromagnetic fields, ferromagnetic materials, propagation of plane waves in conductors and dielectrics, Snell's law, Fresnel equations, polarization, and radiation from accelerated charges and antennas.

PH 393 - 394 Intermediate Laboratory (0-6) (0-6)4
[PH 294]

Advanced experiments in various branches of physics, including optics, atomic physics, solid state physics and nuclear physics, with opportunities for some independent work by permission of the instructor. Detailed written reports are required.

PH 421 Statistical Thermodynamics (4-0)4
[PH 336]

An integrated study of thermodynamics and statistical mechanics: review of the experimental foundations and historical development of classical thermodynamics; probability and statistical methods of studying macroscopic systems; atomic basis of the laws of thermodynamics and microscopic definitions of thermodynamic quantities using the method of ensembles; entropy and related quantities; TdS equations, Maxwell relations, equations of state, and applications; canonical and grand canonical ensembles; phase transitions; quantum statistics; applications to radiation, magnetism, specific heats, and ideal and nonideal systems; and kinetic theory.

PH 461 **Topics in Nuclear Physics** **(3-0)3**
[PH 336]

This course is designed to familiarize the student with a few research areas in the field of nuclear physics. The topics covered may vary from year to year. They will be chosen from the following list: nuclear constituents, fundamentals of interaction forces, liquid drop model and stability energetics, cross sections, passage of ionizing radiations through matter, alpha-decay, beta-decay and electron capture, gamma-decay and internal conversion, nuclear reaction systematics, fission and fusion, models of nuclear structure, and reaction mechanisms.

PH 472 **Solid State Physics** **(3-0)3**
[PH 421]

Crystal structures, X-ray and neutron diffractions, lattice vibrations, the free electron and the band models of metals, semiconductors and applications, dielectric and optical properties of solids, magnetism, and superconductivity.

PH 495 **Special Research Problems** **(3-0)3**
[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student with emphasis on modern research methods and preparation of results for publication.

PH 496 **Special Research Problems** **(3-0)3**
[Permission of Head of Department and Instructor]

A continuation of PH 495 for a second semester.

AP 311 **Applied Mechanics** **(4-0)4**
[PH 141, MA 208]

Forces and moments. Equilibrium of rigid and deformable bodies. Particle Kinematics. Dynamics of particles and rigid bodies. Work, energy, and momentum. Friction. Mechanical oscillations. Elastic properties and strength of materials. Fluid statics and dynamics.

AP 335 **Applied Modern Physics I** **(3-0)3**
[PH 245, MA 208 or equivalent]

Introductory treatment of modern physics and its applications: Relativity. Quantum mechanics. Atoms and molecules. Kinetic theory and statistical mechanics. Plasma and magnetohydrodynamics. Lasers and applications.

AP 336 **Applied Modern Physics II** **(3-0)3**
[AP 335 or equivalent]

Continuation of AP 335. Elements of solid state physics: Crystal structure. Lattice vibrations. Band theory. Semiconductors and applications. Magnetism and applications. Supercon-

ductivity. Elements of nuclear physics: Radioactivity. Accelerators. Reactors. Fission. Fusion.

AP 354 Applied Electromagnetism (4-0)4

[PH 245, MA 208]

Charges, fields, and potentials. Dielectric materials and applications; piezoelectrics. Magnetic field. Magnetic materials and applications; ferrites. Induced emf and inductance. Conductors. Maxwell equations and wave propagation.

AP 381 or 382 Physical Acoustics* (3-0)3

[PH 142, MA 208 or equivalent]

Oscillations. Vibrations and strings. Plane sound waves. Spherical waves and radiation. Sound sources. Sound detectors. Sound recording. Speech, hearing, noise, and communication. Acoustics in architecture. Acoustic measurements and instruments. Ultrasonics. Underwater sound.

AP 445 or 446
X-Ray Diffraction and Crystal Structure* (2-3)3

Elementary crystal structure. Generation and production of X-rays. Diffraction of X-rays by crystals. Elementary theory of scattering from electrons and atoms. Analytical methods: Laue patterns, rotation and oscillation patterns, powder patterns. Cameras and diffractometers. Applications to metallurgical and solid state problems.

Lectures will be supplemented by laboratory work.

Open to students from other departments, by permission of the instructor.

AP 447 or 448 Lasers and Masers* (3-0)3

[AP 335 or equivalent]

Introductory treatment of lasers, masers, and their applications: Interaction of radiation with matter including electric and magnetic dipole transitions. The concept of stimulated emission. Rate equations. Optical resonators. Collision and line broadening processes. Study of various gaseous and solid state lasers and masers. Applications to harmonic generation, holography, and optical modulation techniques.

AP 445 or 456 Plasma Physics* (3-0)3

[AP 354, PH 421 concurrently]

An introduction to the field of plasma physics and its applications. Hydrodynamic equations. The Boltzmann equation. Motion of charged particles in electric and magnetic fields. Propagation of electromagnetic waves in plasma. Collision and radia-

tion processes. Longitudinal oscillations of electrons and ions. Transport processes. Instabilities. Topics from solid state plasmas. Applications.

AP 457 Physical Electronics* (3-0)3
[AP 335 or equivalent, concurrently]

Elements of quantum mechanics. Statistics. Electron emission from solids. Vacuum devices and gaseous processes. Semiconductors and their devices; diodes and transistors. Electron beams; the klystron. Modern amplifiers; the maser, the laser, and magnetotron. Noise.

*Offered when there is sufficient demand.

NOTE: Courses in the 500 Series are primarily intended for graduate students although they may be elected by well qualified undergraduate students.

PH 505-506 Mathematical Methods of Physics (4-0) (4-0)8
[Permission of Instructor]

Complex variables: Cauchy's theorem. Taylor and Laurent series, analytic continuation, the residue theorem, the gamma function, the saddle point approximation, asymptotic series. Fourier series. Fourier and LaPlace transorms. Partial differential equations and boundary value problems. Ordinary second order differential equations. Legendre functions. Bessell function. The Strum-Liouville program, eigen functions and eigen-values. Green's Functions. Integral equations.

PH 507 High-Energy Physics (3-0)3
[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, dispersion relations, Regge poles and unitary symmetry.

PH 511-512 Classical Mechanics (3-0) (3-0)6
[Permission of Instructor]

Variational principles and Lagrange's equations, homonomic and non-holonomic constraints. Hamilton's principle. Central force motion. Orthagonal transformations, rigid body motion. Principle of least action, canonical transformations, Poisson brackets, Hamilton-Jacobi theory. Small oscillations. Classical field theory.

PH 515-516 **Quantum Mechanics** **(4-0) (4-0)8**
[PH 511-512]

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory.

PH 512-522 **Statistical Mechanics** **(3-0)3 (3-0)6**
[Permission of Instructor]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 557-558 **Electricity and Magnetism** **(3-0) (3-0)6**
[PH 505-506 Concurrently and Permission of Instructor]

Electrostatics and magnetostatics with special attention to boundary value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering and applications to the problems of modern-day physics.

PH 560 **Applied Quantum Mechanics** **(3-0)3**
[PH 515-516]

Relativistic Dirac equation of the electron and its simple applications. Symmetry principles in quantum mechanics and elements of group theory. Introduction to many body theory. Hartree Fock self-consistent calculations, and their applications to the theory of many electron atoms, and the nuclei of atoms. Emission and absorption of radiation by quantum systems such as atoms and nuclei. Widths and intensities of spectral lines. Selection rules. Electric and magnetic multipole moments of nuclei and e.m. transition probabilities for nuclei.

PH 561-562 **Nuclear Physics** **(3-0) (3-0)6**
[Permission of Instructor]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 573 Advanced Theory of Solids I (3-0)3

[Permission of Instructor and PH 516]

Lattice vibrations and their interactions with X-rays, neutrons and light. The band model of solids and energy band calculations. The Fermi surface. Transport and optical properties in metals and semiconductors.

PH 574 Advanced Theory of Solids II (3-0)3

[PH 573]

Magnetism and magnetic resonance. Superconductivity. Many-body theory and its applications. Collective excitations. Green function techniques in solid state physics.

PH 575-576 Neutral Particle Transport (3-0) (3-0)6

[Permission of Instructor]

Boltzmann and integral transport equations. Spherical harmonic and variational methods. Corrections to diffusion theory. Special methods of solving transport equations. Adjoint functions. Applications.

PH 583-584 General Theory of Relativity (3-0) (3-0)6

[Knowledge of Special Relativity including Tensor Notation]

Review of Newtonian gravitational theory and special relativity. The weak and strong principles of equivalence. Tensor analysis in Riemann spaces. Einstein's equations for the gravitational field. Classic tests of Einstein's theory; spherically symmetric solutions. Gravitational firld theory and the canonical analysis of general relativity.

PH 593-594 Graduate Laboratory (0-9) (0-9)6

[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

AP 586 Semiconductors (3-0)3

[Permission of Instructor]

Transport and optical properties of Semiconductors. Statistics, collision mechanisms, and band structure. Hot electrons. High magnetic field phenomenon. Devices; Junctions and transistors; Gunn oscillators; semiconductor lasers. (This is the first of a proposed series of Applied Physics courses which is being developed).

PH 942 **Physics** **(4-3)4**

[46.22]

[For Engineering Technology students only]

Elements of electricity and magnetism: Coulomb's law, electric fields, Gauss' law, potential, current, dc circuits, magnetic fields and forces, induced emf, ac circuits.

INDUSTRY ADVISORY COMMITTEE

Nuclear

Dr. Ernest F. Blase, Department of the Navy.

Mr. Roger J. Coe, Yankee Atomic Electric Company

Mr. Joseph J. Fitzgerald, Cambridge Nuclear Corporation

Dr. Thomas H. Johnson

Dr. Jacob H. Jurmain, E G & G, Inc.

Dr. Marvin G. Schorr, Technical Operations, Inc.

NUCLEAR ENGINEERING

The Nuclear Engineering course is offered by the Department of Physics and Applied Physics. It was the first course of its kind taught in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

Six general electives are required and can be selected from the elective system with the exception of LL 261-262 and EC 301 through EC 414.

NUCLEAR ENGINEERING PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA	131		
or			
MA	133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	126	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
*PH	144	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	231		(4-0)4
or			or
MA	233	College Math III or Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
*PH	245	Physics	(4-1)4
		General Elective	(3-0)3
		Total Hours	(17-1)17 or (16-1)16

*PH 247 Honors Physics may be substituted

Second Semester

MA	232		(4-0)4
or			or
MA	234	College Math IV or Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
NU	206	Nuclear Instrumentation	(2-4)4
*PH	246	Physics	(4-1)4
		General Elective	(3-0)3
		Total Hours	(16-5)18 or (15-5)17

*PH 248 Honors Physics may be substituted

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	242	Thermodynamics	(3-0)3
NU	301	Nuclear Engineering	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
		General Elective	(3-0)3
		Total Hours	(14-4)16

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
ME	382	Fluid Mechanics I	(3-0)3
NU	302	Nuclear Engineering	(3-0)3
		Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total Hours	(15-0)15

SENIOR YEAR

First Semester

ME	343	Heat Transfer	(3-0)3
NU	401	Advanced Nuclear Reactor Engineering	(3-0)3
NU	497	Computer Programming and Applications I	(3-2)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total Hours	(15-2)15

*ROTC students may substitute AS 401

Second Semester

NU	402	Advanced Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
		Technical Elective	(3-0)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total Hours	(12-6)15

*ROTC students may substitute AS 402

RECOMMENDED TECHNICAL ELECTIVES

CE	312	Structures I
CE	313	Structural Analysis
CH	484	Elements of Radiochemistry
EE	355	Introductory Electromechanics
EE	443	Electrical Power Systems I
EE	444	Electrical Power Systems II
MA	383	Introduction to Statistics
MA	407	Introduction to Probability Theory
MA	442	Boundary Value Problems
MA	445	Operational Calculus
ME	211	Mechanics I
ME	220	Mechanics of Materials
ME	395	Materials Science
ME	419	Nondestructive Evaluation Techniques
ME	472	Experimental Stress Analysis
ME	473	Mechanics of Materials II
ME	474	Thermodynamic Applications
ME	475	Physical Metallurgy
ME	534	Transport Processes
ME	535	Advanced Heat Transfer
NU	404	Reactor Design
NU	495	Special Nuclear Problems
NU	498	Computer Programming and Applications II
NU	499	Computer Methods and Numerical Analysis
RS	401	Principles of Radiation Safety and Control
RS	402	Principles of Radiation Safety and Control
RS	422	Environmental Radiation and Nuclear Site Criteria

NUCLEAR ENGINEERING COURSE DESCRIPTIONS

NU 201 Introduction to Nuclear Engineering (3-0)3

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission.

NU 202 Introduction to Nuclear Engineering (3-0)3

Utilization of nuclear energy. Nuclear Reactors. Fuels and fuel processing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 206 Nuclear Instrumentation (2-4)4

The lectures cover the fundamentals of circuit theory as applied to pulse circuits encountered in nuclear counting systems. The laboratory offers experiments involving: the study of the characteristics of vacuum tubes and transistors; construction and operating characteristics of power supplies, amplifiers and oscillators; the principles of feedback; construction of pulse and digital circuits; binary, mono and astable circuits; trigger and coincidence circuits.

NU 301 Nuclear Engineering (3-0)3
[NU 201, NU 202]

Nuclear forces and energy; semi-empirical mass formula; binding energy; fission; reactors; radioactivity; interaction of radiation with matter; neutron cross sections, temperature, flux; diffusion theory.

NU 302 Nuclear Engineering (3-0)3
[NU 201, NU 202]

Nuetron lethargy; Fermi age theory; the unreflected reactor; one-group, two-group, age-diffusion theories; reflector savings; homogeneous reactor systems; heterogeneous reactor systems; slightly-enriched, water-moderated lattice systems; fast breeder reactors; reactor kinetics, reactor temperature coefficients; fission product poisoning, reactor control and operation.

NU 305 Nuclear Instrumentation (2-4)4
[NU 206]

The lectures review the interaction of nuclear radiation with matter, the design and operating characteristics of nuclear detectors and their use. The laboratory is devoted to studying the characteristics of detectors, their use in nuclear experiments dealing with radioactive decay and properties of nuclear radiation.

NU 401 Advanced Nuclear Engineering (3-0)3
[NU 301, NU 302]

Energy removal: design of the cooling system, heat transmission principles, heat-transfer characteristics of fluids, heat transfer to boiling liquids, core hydraulics, reactor coolants. Reactor structural and moderator materials; reactor fuels; separation of isotopes, material properties, reprocessing, waste disposal.

NU 402 Advanced Nuclear Engineering (3-0)3
[NU 301, NU 302]

Principles of reactor shielding; thermal stresses in reactor components; pressure vessel design; mechanical and structural components; preliminary reactor design: pressurized-water reactor, thermal and hydraulic design, shield design, mechanical design, fuel utilization; fluid-fuel reactors; space power units; nuclear power costs.

NU 404 Nuclear Reactor Design (3-0)3
[NU 301, NU 302]

A group design project in which the class participates in the overall design of a nuclear power plant system, integrating the requirements of reactor physics, control, heat transfer, thermodynamics, fuel cycle, economics, safety, siting and radiological and environmental effects. Each member of the class will be responsible for a particular aspect of the design.

NU 494 Advanced Nuclear Laboratory (0-6)3
[NU 305]

Neutron activation experiments. Flux mappings by foil and counter techniques. Measurements of slowing down lengths, diffusion lengths and Fermi age. Control rod studies and effects of poisoned moderators. Additional experiments on accelerator and reactor using advanced instrumentation and techniques.

NU 495 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

NU 496 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Continuation of NU 495 for a second semester.

NU 497 Computer programming and Applications I (3-0)3

Overview of the structure of modern digital computers. Number systems and computer representation of alphanumeric data. Programming in FORTRAN-4 language, including the running of about 10 programs. A survey of the computer's operating system software.

NU 498 Computer Programming and Applications II (3-0)3
[NU 497]

Programming in symbolic assembler language. Introduction to computer systems programming using the computer's interrupt structure. Introduction to real-time environment with applications in nuclear engineering.

NU 499 Computer Methods and Numerical Analysis (3-0)3
[NU 497]

Computer methods in the solution of engineering and physics problems using numerical analysis techniques. Topics include: error analysis, solution of algebraic, transcendental and polynominal equations, quadrature formulas for numerical integration, systems of linear equations, matrix manipulation, interpolation techniques, numerical differentiation, solution of differential equations, and curve fitting using linear and nonlinear least square methods.

NU 505 Reactor Physics (3-0)3

Nuclear reactions induced by neutrons: cross sections, fission; diffusion and slowing down of neutrons; Diffusion, Fermi age and multigroup treatment of unreflected and reflected homogeneous reactors, reactor design parameters.

NU 506 Reactor Physics (3-0)3

Reactor physics problems relating to the operation and kinetics of a nuclear reactor. Effect of poisoning, and temperature on design criteria; excess reactivity; elementary reactor kinetics, perturbation theory and control rod theory. Introduction to transport theory.

NU 507 Reactor Engineering (3-0)3

Analysis of nuclear energy conversion and removal from nuclear fueled reactors. Detailed analysis of heat generation and heat transfer including fluid dynamics of various reactor systems.

NU 508 Reactor Engineering (3-0)3

Continuation of NU 507. Analysis of reactor systems including power cycles, heat transfer, fuel management, economic analysis and basic reactor control theory.

NU 509 Fast Reactors (3-0)3

General characteristics of fast reactors. Breeding cycles and plutonium production; neutron balance, breeding ratio and doubling time. Simplified methods for fast reactor calculations. Kinetics, control and safety of fast reactors; sodium void and doppler coefficients. Engineering consideration and design concepts in large, fast power reactors.

RADIOLOGICAL HEALTH PHYSICS

The Radiological Health Physics Program offered by the Department of Radiological Sciences is designed to provide needed professional personnel to help advance the safe utilization of nuclear energy and radiation. It is conducted through the cooperation of other departments and provides the best education and experience within the practical limitations imposed by time and resources to carefully selected and highly motivated students. The program is supported by the Bureau of Radiological Health of the Department of Health, Education and Welfare. The program includes specialized training and education during the summer months, summer internship programs, and scholarships for qualified students.

The academic program is broad based in the basic sciences so that students will be able to recognize and appreciate the many complex and interrelating factors in the solution of problems facing the nuclear industry.

Students will benefit from cooperative summer training programs utilizing the radiation facilities and staff of the LTI Nuclear Center, government laboratories, industries, and major hospitals. This training and education in the nuclear sciences and radiological health gives experience with equipment and methods characteristic of current techniques and philosophy of professional practice in the radiation protection field. The summer program enables students to better select a professional position after graduation and better equips them for the pursuit of advanced degrees and research in the field.

RADIOLOGICAL HEALTH PHYSICS PROGRAM

FRESHMAN YEAR

First Semester

*CH	121	Chemistry	(3-0)3
CH	123	Chemistry Laboratory	(0-3)1
LL	111	English I	(3-0)3
MA or MA	131 or 133	College Math I or Calculus I	(4-0)4
*PH	141	Physics	(3-1)3
FS	001	Frosh Seminar	(1-0)
PE	101	Physical Education	(0-2)1
		Total Hours	(14-6)15

*CH 127 Honors Chemistry and PH 147 Honors Physics may be substituted

Second Semester

*CH	126	Chemistry	(3-0)3
CH	124	Chemistry Laboratory	(0-3)1
LL	112	English II	(3-0)3
MA	132		
or			
MA	134	College Math II or Calculus II	(4-0)4
*PH	144	Physics	(4-1)4
PE	102	Physical Education	(0-2)1
		Total Hours	(14-6)16

*CH 128 Honors Chemistry and PH 148 Honors Physics may be substituted

Summer

RS	100	Basic Radiological Health Physics	4 weeks Summer

SOPHOMORE YEAR

First Semester

BI	421	The Environmental Biology of Man	(3-0)3
EE	211	Fundamentals of Electricity	(3-0)3
MA	231		(4-0)4
or			or
MA	233	College Math III or Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
*PH	245	Physics	(4-1)4
		Total Hours	(17-1)17 or (16-1)16

*PH 247 Honors Physics may be substituted

Second Semester

LL	210	Technical and Scientific Communication	(3-0)3
MA	232		(4-0)4
or			or
MA	234	College Math IV or Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
NU	206	Nuclear Instrumentation	(2-4)4
*PH	246	Physics	(4-1)4
		Total Hours	(16-5)18 or (15-5)17

*PH 248 Honors Physics may be substituted

Summer

RS	200	Applied Radiological Health Physics	Summer or work experience

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
MA	301	Advanced Calculus for Applications	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
RS	401	Principles of Radiation Safety & Control	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-7)17

Second Semester

BI	462	Radiation Biology	(3-0)3
MA	302	Advanced Calculus for Applications	(3-0)3
RS	402	Principles of Radiation Safety & Control	(3-3)4
		General Elective	(3-0)3
		Total hours	(12-3)13

Summer

RS	300	Applied Radiological Health Physics	Summer or work experience

SENIOR YEAR

First Semester

RS	411	Research in Radiological Sciences or Approved Technical Elective	2, 3, or 4
RS	431	Seminar in Radiological Sciences	(2-0)1
RS	451	Introduction to Electronic Product Radiation	(3-0)3
		General Elective	(3-0)3
		Elective	(3-0)3
		Total credit hours	12, 13, or 14

Second Semester

CH	484	Elements of Radiochemistry	(2-3)3
RS	412	Research in Radiological Sciences or Approved Technical Elective	2, 3, or 4
RS	432	Seminar in Radiological Sciences	(2-0)1
		General Elective	(3-0)3
		Elective	(3-0)3
		Total credit hours	12, 13, or 14

SUGGESTED TECHNICAL ELECTIVES

CN	521	Introduction to Environmental Studies	(3-0)3
MA	361	Digital Computer Programming	(2-0)2
MA	383	Statistical Methods	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
RS	422	Environmental Radiation & Nuclear Site Criteria	(3-0)3
RS	501	Radiation Physics and Shielding Design	(3-0)3
RS	503	Introduction to Radiation Chemistry	(3-0)3
RS	506	Radiation Dosimetry	(3-3)4
RS	507	Criticality and Nuclear Reactor Safety	(3-0)3

RADIOLOGICAL SCIENCES COURSE DESCRIPTIONS

RS 100 Basic Radiological Health Physics 4 weeks

[Primarily for RS students]

Introduction to atomic and nuclear physics; natural and artificial radioactivity, radiation, decay schemes; nuclear reactions including fission and fusion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations; principles of radiation detection and detection devices; counting systems and assay of α, β, γ emitters; survey and monitoring equipment; external radiation exposure and protection techniques; radiation safety and control; accelerator and reactor health physics; medical radiation physics and X-ray protection.

RS 200 Applied Radiological Health Physics Summer of work experience

[Primarily for RS students]

Applied work experience during summer months as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 300 Applied Radiological Health Physics Summer of work experience

[Primarily for RS students]

Applied work experience during summer months as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution.

RS 401 Principles of Radiation Safety and Control (3-0)3

[NU 202 or equivalent]

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material.

RS 402 Principles of Radiation Safety and Control (3-0)3

[NU 202 or equivalent]

A laboratory course giving students experience with equipment and practices of current use in the radiation protection field, an extension of RS 401 giving some of the practical aspects of radiation safety and control.

RS 411-412 Research in Radiological Sciences 8

[Primarily for RS students]

A research problem related to the field of radiation protection is investigated by the student under the direction of faculty and staff of the Nuclear Center. The student will present a seminar on his research project. Areas of research anticipated include radiation shielding, radiation detection and measurement, radiation survey and monitoring, radiation biology, radiation chemistry, radiobiology, radiochemistry radioecology, natural radioactivity, fall out, analyses and measurement of radioactivity and radiation levels associated with the operation of reactors and accelerators, and radioactive aerosols.

RS 422 Environmental Radiation and Nuclear Site Criteria (3-0)3

[Permission of Instructor]

Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, aquatic and terrestrial ecosystems; design and operation of environmental surveillance programs around nuclear facilities; reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations; environmental impact of nuclear reactors.

RS 431-432 Seminar in Radiological Sciences (2-0)1 (2-0)1

[Primarily for RS students]

Guest speakers and staff of the Nuclear Center present not only topics of current interest to the field of radiation protection but also descriptions of radiological health physics programs at various nuclear and radiation facilities. Students present a seminar either on their research project or on their critical essay.

RS 441 Radioisotope Techniques (3-3)4

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Integrated into both laboratory and lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities.

RS 451 Introduction to Electronic Product Radiation (3-0)3

[Permission of Instructor]

The theoretical and applied aspects of the generation, measurement, and uses of radiant energy from electronic products

whose emissions span the entire electromagnetic spectrum; ultrasonic energy emitted by electronic products; biological effects, standards of protection and control, and consequences and intent of Public Law 90-602.

RS 501 Radiation Physics and Shielding Design (3-0)3
[Permission of Instructor]

Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding of point, surface, and volume sources; shielding design factors in reactor and accelerator operation.

RS 503 Introduction to Radiation Chemistry (3-0)3
[Permission of Instructor]

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination.

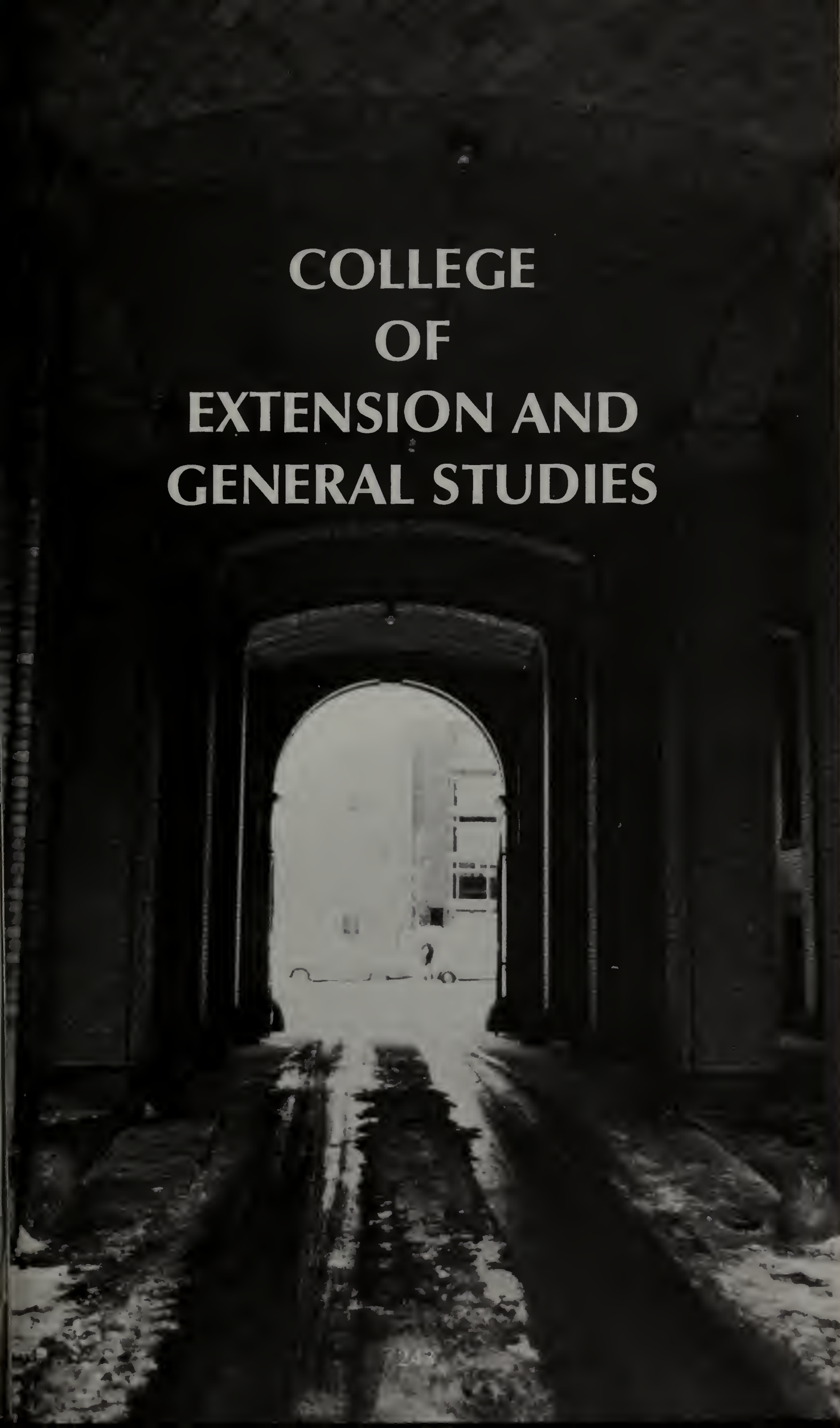
RS 506 Radiation Dosimetry (3-3)4
[Permission of Instructor]

Sources of radiation exposure; calculations of chronic and acute radiation doses and their effects; internal dosimetry including distribution and elimination of radioisotopes; alpha, beta, gamma, and neutron dosimetry; principles of charge measurement and energy transfer; use and calibration of instruments including solid state dosimeters, ion chambers, and extrapolation chambers.

RS 507 Criticality and Nuclear Reactor Safety (3-0)3
[Permission of Instructor]

Considerations of safe practices in transportation, storage, handling, and use of fissionable materials. Effects of moderators, reflectors, and geometrics in thermal, epi-thermal and fast assemblies. Natural and engineered safeguards are discussed.

COLLEGE OF EXTENSION AND GENERAL STUDIES



COLLEGE OF EXTENSION AND GENERAL STUDIES

The College of Extension and General Studies is a group of departments, schools and programs which (except for the Evening School) do not offer curricula leading to a degree. They are support areas to the overall educational programs of the Institute. They are as follows:

Evening School
Continuing Education and Summer School
Department of Aerospace Studies
Department of Languages and Literature
Department of Physical Education
Department of Social Sciences
The Martin Luther King, Jr. Educational Opportunity Program
Libraries

Descriptions of the courses and programs offered, and other pertinent information about these schools, departments and programs are given in an appropriate location in the catalogue. The Evening School and Continuing Education and Summer School have separate catalogues describing their programs in greater detail.

FACULTY

Edward L. Alexander, B.S., M.S., Ph.D., Acting Dean

Chairmen of Departments

Richard M. Aronson, B.S., M.Ed., C.A.S., Physical Education

James H. Aikman, Col., U.S.A.F., B.G.E., M.S., Aerospace Studies

John J. McCaffrey, A.B., A.M., Languages and Literature

Francis R. Walsh, B.S., M.A., Ph.D., Social Sciences

Members

Department of Aerospace Studies

James H. Aikman, Col., USAF, B.G.E. (University of Nebraska), M.S. (University of Southern California), Professor

Bruce Baron, Capt., USAF, B.S. (Lowell Technological Institute), M.S. (Air Force Institute of Technology), Assistant Professor

Charles B. Simons, Major., USAF, A.B. (Trinity College), M.Ed. (University of Southern California), Assistant Professor

Languages and Literature

William M. Aiken, B.A. (Trinity College), A.M. (Harvard University), Assistant Professor

Donald R. Berry, B.A., M.A. (Baylor University), Assistant Professor

Andrea Broderick, B.A. (University of New Hampshire), M.A. (Vanderbilt University), Instructor

William F. Coughlin, Jr., B.S. (Lowell State College), A.M. (Middlebury College), Instructor, Ed.D. (University of Massachusetts, Amherst).

Arthur T. Dabilis, A.B. (Suffolk University), M.A. (Northeastern University), Instructor

Robert J. DeYoung, B.A., M.A. (New York University), Assistant Professor

Richard R. Forster, B.A. (Louisiana State University), M.A. (University of Southern California), Instructor

William R. Hersey, B.S. (Lowell State College), M.A. (Boston College), Instructor

Lester B. Hudson, A.B., M.A. (Boston University), Instructor

Charles E. Jarvis, B.S., M.A. (Boston University), Professor

Marianne H. Knowlton, B.A. (Smith College), M.A. (Tufts University), Assistant Professor (on leave)

John J. McCaffrey, A.B. (Suffolk University), A.M. (Tufts University), Assistant Professor

Barbara Miliaras, A.B., Ed.M. (Boston University), Instructor

Howard K. Moore, A.B., A.M. (Boston University), M.L.S. (Simmons College), Ph.D. (Boston University), Professor and Director of Libraries (on leave 2nd semester)

William L. Mulcahy, Jr., B.A. (Harvard University), M.Ed. (Salem State College), Instructor

Gerard W. O'Connor, A.B. (Harvard University), A.M., Ph.D. (Boston University), Professor

John J. Riley, A.B., M.A. (Boston University), Ph.D. (Tufts University) Assistant Professor

Charles J. Ryan, B.A. (University of Connecticut), M.A. (University of Massachusetts), Instructor

Anthony C. Turrisi, B.S. (Massachusetts Institute of Technology), M.A. (University of Wisconsin), Instructor

Robert J. Whelan, B.S. (Boston College), M.A. (Catholic University of America), Assistant Professor

Roger E. Wiehe, B.A. (Yale University), M.A. (University of Illinois), Ph.D. (Columbia University), Professor

Physical Education

Richard M. Aronson, B.S. (Springfield College), M.Ed. (Boston University), C.A.S. (Springfield College), Assistant Professor

Robert T. Callary, B.S. (Springfield College), M.Ed. (Fitchburg State College), Instructor

A. Grant Carrow, A.B. (University of New Hampshire), Instructor

A. James Oliver, B.S. (Boston University), M.Ed. (Boston State College), Associate Professor

William J. Riley, Jr., B.S. (Boston University), M.Ed. (Boston University), Instructor

James E. Stone, B.S. (Springfield College), Assistant Professor

Social Sciences

Jeannette Bowen, B.S., (Boston State College), Instructor

Stanley J. Chase, A.B., M.A. (Siena College), Assistant Professor

William S. Harrison, A.B. (Harvard University), Assistant Professor

Jonathan J. Liebowitz, A.B. (Columbia University), M.A., Ph.D. (University of California, Berkeley), Assistant Professor

Joseph W. Lipchitz, B.A., M.A. (University of Massachusetts), Ph.D. (Case Western Reserve University), Associate Professor

William G. Nowlin, Jr., B.A. (Tufts University), M.A. (University of Chicago), Instructor

Miriam D. Price, A.B. (Smith College), Instructor (on leave 1st semester)

Joan A. Rothschild, A.B. (Cornell University) M.A., Ph.D. (New York University), Instructor

Francis R. Walsh, B.S., M.A., Ph.D. (Boston University), Professor

Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston University), P. Ed. (University of Connecticut), Associate Professor

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men and women who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC), the first two college years, and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Four-Year AFROTC Program or the Two-Year AFROTC Program. Students electing the Four-Year Program will take the General Military Course during their freshman and sophomore years and the Professional Officer Course during their junior and senior years. They will attend four weeks of field training during the summer between the sophomore and junior years. As members of the program they are eligible to compete for AFROTC Scholarships. For acceptance into the POC, the Four-Year Program student must pass a physical examination, an Officer Qualification Test, and possess an acceptable academic rating. To qualify for enrollment in the Two-Year Program, students must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. They must also meet certain physical standards, pass an Officer Qualification Test, and possess an acceptable academic rating. Further, they must successfully complete a six-week Field Training Course before they can be accepted into the Professional Officer Course. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the Institute and the United States Air Force. Students in the Professional Officer Course receive a $100.00 per month subsistence allowance. Additionally, scholarships are available to a limited number of cadets in the program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. They serve on active duty in the Air Force in a specialty as close as possible to their academic training consistent with AF needs.

GENERAL MILITARY COURSE

FRESHMAN YEAR

First Semester

AS	101	U.S. Military Forces in the Contemporary World I	(1-1)1

Second Semester

AS	102	U.S. Military Forces in the Contemporary World II	(1-1)1

SOPHOMORE YEAR

First Semester

AS	201	U.S. Military Forces in the Contemporary World III	(1-1)1

Second Semester

AS	202	U.S. Military Forces in the Contemporary World IV	(1-1)1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

First Semester

AS	301	Growth and Development of Aerospace Power I	(3-1)3

Second Semester

AS	302	Growth and Development of Aerospace Power II	(3-1)3

SENIOR YEAR

First Semester

AS	401	The Professional Officer I	(3-1)3

Second Semester

AS	402	The Professional Officer II	(3-1)3

The AFROTC program is recognized as academic but of a highly specialized nature. It is not a requirement for graduation and students may not use more than six (6) credit hours of the Professional Officer Course (junior and senior year subjects) in substitution for other subjects taken for graduation. Subjects taken in the ROTC program in the freshman and sophomore

years are to be taken in addition to all other subjects listed in the various curricula. Academic credit is given for all ROTC subjects taken and passed and the grades will affect the student's academic rating. Unless otherwise specified in the section on each curriculum, the six credit hours of advanced ROTC may be elected instead of General Electives.

CORPS TRAINING

Corps Training is conducted one hour each week. It is an assembly of the entire cadet corps under the direction of the detachment officer staff. The General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to plan, organize and supervise cadet activities. During periods of inclement weather, Corps Training is conducted indoors and consists of programs to familiarize cadets with the life and work of Air Force officers and the base environment in which they function. Experts in the fields of Defense Policy and other current affairs subjects also lecture in the AFROTC Enrichment Program to broaden the student's appreciation in these areas.

FIELD TRAINING

Each cadet must attend field training during the summer before entry into the Professional Officer Course. Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $280.00 for the four-week Field Training and $460.00 for the six-week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of dual and solo flight instruction by a FAA certified civilian flying school at government expense.

CADET DECORATIONS AND AWARDS

A number of medals and awards are presented to selected cadets at special ceremonies held each semester. These awards include the Disabled American Veterans (DAV), the Costello Trophy, American Legion Excellence Awards, the Reserve Officer Association Medal, the LTI Trustees' and Alumni Awards.

In addition, the Department of Aerospace Studies confers several medals and awards, among them the Distinguished Military Cadet Award, for outstanding performance in various fields.

Distinguished AFROTC Graduate Awards, based on academic and military achievements, are given to outstanding graduates. These awards constitute an advantage in competing for a Regular Air Force commission.

AEROSPACE STUDIES COURSE DESCRIPTIONS

AS 101-102 U.S. Military Forces in the Contemporary World I and II (1-1) (1-1)2

An introductory course exploring the background, mission, and functions of U.S. Military Forces. Particular emphasis is placed upon the mission and organization of the US Air Force and the responsibilities of an Air Force officer. The course continues with an in-depth study of US strategic offenses and defensive forces and ends with an examination of the specific functions of US General Purpose and Aerospace Support Forces. This study will serve as a foundation for an introduction to the defense policy instruction offered in AS 201-202.

AS 201-202 U.S. Military Forces in the Contemporary World III and IV (1-1) (1-1)2

A brief study of defense policies as related to the strategies of the United States, the Soviet Union and China. The course continues with the study of defense organization, the role of the military in United States national policies and concludes with an examination of the factors involved in defense decision making.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the changing nature of military conflict; airpower in the United States; mission and organization of the U.S. Air Force; Air Force concepts, doctrine and employment of aerospace power, including US space programs, vehicle, systems, and problems in space exploration. These areas are studied through the media of briefings, discussions, debates and written reports by the students to improve their communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership and introductory management principles. Classroom and organizational situations allow application of leadership and management skills, stress professional and personal responsibility and improve communicative skills through classroom discussions and student presentations.

LANGUAGES AND LITERATURE COURSE DESCRIPTIONS

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 207 Oral Business Communication (3-0)3

[LL 111-112]

Techniques and ethics of oral presentation. Panels, discussions, and problems. Frequent use of language laboratory. Limited to fifteen students.

LL 210 Technical and Scientific Communication (3-0)3

[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature: to 1798 (3-0)3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature: from 1865 (3-0)3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature: (3-0)3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature: from 1798 (3-0)3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature from 1798.

LL 218 Afro-American Literature (3-0)3

[LL 111-112]

A study of poems, plays, short stories and novels by Negro-

Americans from 1920 to the present, including Langston Hughes, Richard Wright, James Baldwin, Ralph Ellison, and others.

LL 219 The Film in Communication (3-0)3
[LL 111-112]

The film as a medium for communication. Historical evolution of screen conventions. Emphasis on analysis and evaluation of film.

LL 224 Literary Criticism for the Technology Major (3-0)3
[LL 111-112]

Familiarizes the student with the biographical, psychological, sociological, and analytical approaches to literature. Application to works by Poe, Crane, Hemingway, Camus, and others.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 235 English Drama Before 1700 (3-0)3
[LL 111-112]

A study of the origin and development of English dramatic literature from the medieval period to 1700. Reading and discussion of representative types of plays: mystery, miracle, morality; Elizabethan comedy, tragedy and history; Restoration comedy of manners and heroic play. Emphasis on works of Marlowe, Johnson, Dryden, Wycherley, and Congreve.

LL 236 English Drama After 1700 (3-0)3
[LL 111-112]

A study of the major trends in English dramatic literature from 1700 to the present. Reading and discussion of representative types of plays: sentimental comedy, bourgeois tragedy, satire, problem play, "well-made" play, modern verse drama, theatre of the absurd. Emphasis on works of Lillo, Rowe, Goldsmith, Sheridan, Shaw, Osborne, and Beckett.

LL 238 Science and Literature (3-0)3
[LL 111-112]

Primarily a study of literary and other non-scientific works that deal with science and its cultural implications. Major topics will include (1) the controversy over the "two cultures," (2) the scientist as hero, (3) science fiction, (4) some aspects of the history of science. Wide range of readings from Lucretius to Brecht's *Galileo*.

LL 259-260 Elementary German (3-0) (3-0)6

Fundamentals of grammar and basic vocabulary. Audio-lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use.

LL 261-262 Elementary Technical German (3-0) (3-0)6

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology.

LL 263-264 Elementary French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. For students who have had less than two years of secondary school training in French.

LL 265-266 Elementary Russian (3-0) (3-0)6

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing skills in reading and writing.

LL 269 Literature of the Beats (3-0)3

[LL 111-112]

A study of the Beat writers of the 1950's and 1960's: Kerouac, Ginsberg, Burroughs, Corso, Ferlinghetti, and two or three others. An examination of the Beat Rebellion and its influence on the American scene today. Resources: tapes, letters, guest speakers, and other primary sources.

LL 309 Woman in Modern Fiction (3-0)3

[LL111-112]

A study of the changing role of women in our society as viewed and recorded by the literary artist. The study will extend from Thomas Hardy and D.H. Lawrence to the present, and con-

centrate finally on the current Liberation movement.

LL 311 Creative Writing and Advanced Composition (3-0)3
[LL 111-112]

A course designed to develop the student's natural ability in verbal expression. Original works of short fiction, poetry, and exposition will be presented and discussed at regular intervals throughout the term.

LL 315 Myth and Symbol in Literature (3-0)3
[LL 111-112]

An examination of the use of myth and symbol in modern literature for its thematic and cultural-historical significance. Emphasis on the analysis literature selected from the works of Dostoevski, Gide, Mann, Conrad, D.H. Lawrence and others.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 318 The Evolution of the Existential Hero (3-0)3
[LL 111-112]

The development of the alienated hero in fiction from Stendhal, and Camus with emphasis upon the works of the following authors: Stendhal; Melville; Dostoevski; Gide; Sartre; Camus; Hemingway and Beckett.

LL 319-320 The Image of Man in Western Thought (3-0) (3-0)6
[LL 111-112]

The first semester is not a prerequisite to the second. Examination of the major ideas and cultural influences in Western Thought from the fall of Rome to the present as reflected in literature, the visual arts and music.

Semester I: The Latin Middle Ages to the French Revolution
Semester II: The Industrial and Scientific Revolution to the Emergence of the Absurd.

LL 333 Problems of Philosophy (3-0)3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 335 Modern Southern Fiction (3-0)3
[LL 111-112]

An investigation of universal implications in "regional" literature: Faulkner, Flannery O'Connor, Robert Penn Warren, Eudora Welty, James Agee, William Styron, Ralph Ellison, Truman Capote, James Baldwin.

LL 341 **Satire** **(3-0)3**
[LL 111-112]

A study of a literary genre. Selected readings form Horace and Jevenal through Orwell and Burgess.

LL 342 **Utopian Literature** **(3-0)3**
[LL 111-112]

A study of utopias from Plato through Bacon to Bellamy, Wells, and Clarke.

LL 344 **Modern American Poetry** **(3-0)3**
[LL 111-112]

An inductive investigation into recent trends in American verse, using the work of Frost, Pound, Eliot, and Williams as instructive points of departure and culminating in student investigation and individual poets of special interest.

LL 345 **Modern Irish Literature** **(3-0)3**
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 **Intermediate French** **(3-0) (3-0)6**
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit.

LL 365-366 **Intermediate Literary and Conversational Russian** **(3-0) (3-0)6**
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records.

LL 367-368 **Intermediate German** **(3-0) (3-0)6**
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idiomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of sinificant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use.

LL 369-370 Intermediate Spanish (3-0) (3-0)6

[LL 268 or equivalent]

Intensified study of the language, with increased opportunity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits.

LL 371 Literatura de la America Hispanica (3-0)3

[LL 369-370 or equivalent]

Reading, analysis, and discussion of typical literary works of authors of the 18th, 19th, and 20th centuries. Conducted in Spanish.

LL 431 Philosophy of Science (3-0)3

[LL 111-112]

Consideration of the hypothetico-inductive method of gaining knowledge, the significance of causality and its problems, the principles of induction, empiricism, relations between physical and biological sciences, logical models for scientific discovery. Historical examples will be used.

LL 435 English Literature of the Eighteenth Century (3-0)3

[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectual background.

LL 436 English Romantic Poets (3-0)3

[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

LL 443 Science Fiction (3-0)3

[LL 111-112]

A study of major works in science fiction and fantasy from Wells and Tolkien through Heinlein and Delaney. Emphasis is literary and historical.

LL 444 Popular Culture (3-0)3

[LL 111-112]

A study of the Hero in American popular culture. Selected heroes include the Cowboy, the Tough Guy, the Secret Agent, the Politician, the Black, and the Musician. Movies, records, magazines, TV, and popular literature will be used.

LL 467 Seminars in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3

[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3

[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3

[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3

[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected presentative plays are read and discussed.

LL 476 Nineteenth-Century British Novel (3-0)3

[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 481 Classical Literature (3-0)3

[LL 111-112]

An examination of the contributions of the Greeks to our literary culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

LL 482 The Short Story (3-0)3

[LL 111-112]

A critical survey of the growth and development of the short story. Consideration of the works of key writers in this genre.

LL 484 The Modern European Novel (3-0)3
[LL 111-112]

A study of major European novels selected from the works of such writers as Zola, Flaubert, Dostoevsky, Tolstoy, Pasternak, Grass, Camus, Moravia, and Hesse.

LL 495-496 Reading and Research 6
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideration for admission limited to Juniors and Seniors with "B" average.

LL 961 British Literature (3-0)3
[For students in Engineering Technology only]

An introduction to British Literature from the Anglo-Saxon Period to the Contemporary Period, with emphasis on major authors and key periods.

LL 962 American Literature (3-0)3
[For students in Engineering Technology only]

An introduction to the literature of the United States from the Colonial Period to the Contemporary Period, with emphasis on major authors and historical background.

ATHLETICS AND RECREATION

Athletics are a part of the total program at Lowell Tech, and essential to the overall development of the individual. New and extensive facilities and a competent professionally trained staff provide numberless opportunities for students to participate in a variety of activities.

A beautiful new, well-equipped physical education building includes a gymnasium, with a seating capacity of two thousand, an all-purpose gym of equal size to the main gymnasium, a collegiate-style swimming pool, a wrestling and judo room, weight training facilities, a gymnastics area, two handball and three squash courts, home and visiting team dressing rooms, a modern rifle range, and locker rooms for students and faculty with more than two thousand lockers available.

New athletic fields and a skating rink are located in the area adjacent to the physical education building.

An intercollegiate boathouse for L.T.I. is located on the banks of the Merrimack River in Lowell.

The Athletic Association is funded by student fees and provides extensive opportunities for student participation in intercollegiate, intramural, and recreation programs. All students are members of the association and are admitted free to all home athletic contests.

Intercollegiate athletics: Lowell Tech has intercollegiate competition in twenty sports. Teams are scheduled in soccer, club football, and cross country in the fall; basketball, hockey, wrestling, karate, gymnastics, swimming, skiing, squash, bowling, and rifle in the winter; baseball, track, golf, tennis, crew, lacrosse, and cricket in the spring.

Intramurals: The intramural program at L.T.I. is extensive. The three leagues — fraternity, dormitory, and independent — compete in the following activities: touch football, basketball, tennis, golf, bowling, track, cross country, ice hockey, handball, squash, volleyball, badminton, water basketball, table tennis, swimming, wrestling, riflery, paddleball, softball, and archery. Members of the girl's leagues compete in softball, basketball, volleyball, and swimming.

Recreation: The athletic facilities at L.T.I. are open for student use from 9:00 a.m. to 9:30 p.m. weekdays, and from 10:00 a.m. to 4:00 p.m. on Saturdays.

There are opportunities for student participation in the organized and informal recreational activities listed as follows: badminton, volleyball, basketball, physical conditioning, swimming, diving, water basketball, life saving, archery, table tennis, touch football, skin and scuba diving, wrestling, judo, karate, rifle and pistol shooting, weight training, gymnastics, handball, squash,

tennis, ice skating, track and field, softball, and lacrosse.

Equipment needed for most of these sports is available from the Issue Room on presentation of the student's ID card.

Students are urged to supplement their required activities with a regular program of recreation.

PHYSICAL EDUCATION

Physical education makes its contribution to the total college curriculum through specific programs of conditioning exercises, self-testing activities, sports, recreational games, gymnastics, rhythms, aquatic activities, and personal defense activities such as wrestling, judo, and karate. Physical Fitness testing is included as a basic part of the program. The students are expected to become familiar with and develop efficiency in a variety of activities especially team games, individual recreational sports, swimming, and physical fitness.

The classes meet twice a week and are required for Freshmen. Lowell Tech students must pass a swimming test and four quarters of Physical Education. Each quarter is half a semester. Students who satisfy minimum requirements in the swimming and the Physical Fitness Test are allowed to choose any activity which the Department offers. A new activity must be chosen each quarter.

Students who do not satisfy the minimum requirements are assigned a swimming or a Physical Fitness class. At the end of the quarter, these students are retested.

The program is elective for sophomores, juniors, and seniors. After completing the freshman requirement, they may choose those activities in which to receive additional instruction. Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, physical education credit will be given for such participation.

The following objectives serve as guides for the entire program:

1. The improvement of health through increased organic vigor.
2. The development of efficient and effective sports-skills and motor fitness.
3. The development of desirable social attitudes and standards of conduct.
4. The development of an appreciation for an interest in physical activities which will result in continued participation in wholesome and enjoyable leisure pursuits.

PHYSICAL EDUCATION COURSE DESCRIPTIONS

PE 101 Physical Education First Semester

Pass swimming and physical fitness tests and any two of the activities listed under I, II, III, IV, and V.

Those who fail the swimming test must complete P 160 "Swimming for Beginners", and those who fail physical fitness test must complete P 110 "Physical Fitness" in order to get credit for the first semester.

PE 102 Physical Education Second Semester

Pass any two of the activities listed under I, II, III, IV, and V.

I INDIVIDUAL ACTIVITIES

P.	110	Physical Fitness
P.	112	Golf
P.	115	Individual Sports (handball-squash-paddle racquets)
P.	116	Tennis
P.	117	Archery
P.	120	Weight Training
P.	125	Gymnastics
P.	126	Badminton
P.	127	Fencing

II TEAM ACTIVITIES

P.	130	Basketball
P.	135	Hockey
P.	136	Skating
P.	140	Soccer
P.	145	Softball
P.	150	Touch Football
P.	155	Volleyball
P.	156	Indoor Team Games

III AQUATICS

P.	160	Swimming for Beginners
P.	161	Intermediate Swimming
P.	162	Pre Life-saving
P.	163	Life-saving
P.	164	Competitive Swimming
P.	165	Competitive Diving
P.	166	Water Basketball
P.	167	Water Polo
P.	168	Advanced Diving
P.	169	Water Safety Instructor Course
P.	230	Scuba and Skin Diving

IV COMBATITIVES

P.	170	Judo
P.	172	Karate
P.	175	Wrestling

V INTERCOLLEGIATE SPORTS

P.	200	Crew
P.	320	Riflery
P.	321	Track
P.	340	Squash
P.	400	Baseball
P.	405	Basketball
P.	410	Golf
P.	415	Hockey
P.	420	Skiing
P.	425	Soccer
P.	428	Cross Country
P.	430	Tennis
P.	432	Gymnastics
P.	435	Wrestling
P.	460	Lacrosse
P.	465	Swimming
P.	470	Bowling

SOCIAL SCIENCES COURSE DESCRIPTIONS

SS 223 The United States: 1865-1917 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

SS 224 The United States: 1918-1945 (3-0)3

A study of politics and foreign policy from Wilson through Roosevelt.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 226 Europe: 1914 to the Present (3-0)3

A study of the period of the two World Wars and the postwar periods in which totalitarianism, new power alignments, and new international organizations developed.

SS 232 Social and Economic Change in Europe: 1750 to the Present (3-0)3

This course studies the impact of economic change on the life of Europe since the 18th century. After a brief survey of theories of development, the economic revolutions of the past 200 years are examined in depth. The relationships between economic change and social and intellectual life are also explored.

SS 233 Problems Of Modern Ireland (3-0)3

A reading and discussion of present problems of twentieth century Ireland set in their historical perspective.

SS 235 England: Roman Times to the Restoration (3-0)3

The history of England to 1660, with emphasis on the development of the institutions of monarchy and Parliament, culminating in the clash between the two and the Restoration in 1660.

SS 236 England: The Restoration to the Present (3-0)3

England's history from the Restoration, tracing the rise of parliamentary government, the cabinet system, domestic reforms, and imperial policy.

SS 238 Revolutions in European History (3-0)3

An analysis of the causes and effects of the English, French and Russian Revolutions, with some comparisons to revolutions

outside of Europe. The role of revolution in European political and social development.

SS 240 European Urban History (3-0)3

The origins of the city. Changing structure and function of cities in Ancient, Medieval and Early Modern Europe. The industrial city and the city of the future.

SS 242 European Imperialism (3-0)3

The doctrine and practices of European expansion in the 19th century. Economic and political interpretations. The reactions of subject peoples and liberation movements.

SS 301 Government of the United States (3-0)3

This course focuses on contemporary social and political factors in the United States. Readings, discussion, and analysis are used to gain an understanding of the structural and behavioral realities of modern American politics.

SS 303 Psychology (3-0)3

An introduction to the basic principles of human behavior. The major areas covered include the origins and development of psychology as a science, the stages of human development, motivation and emotion, sensing and perceiving, the nature of neuroses and psychoses.

SS 305 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 307 Seminar in Small Group Analysis (3-0)3

Experimental exploration of group processes in industry & business. Members of seminar engage in the task of simultaneously building a group and analyzing group structure and process, applying relevant social psychological theory and principles.

SS 308 Psychology of Interpersonal Behavior (3-0)3

A study of the science of interpersonal behavior and of the development of theories of the personality. Major topic areas discussed include: the meaning and measurement of interpersonal behavior, behavior development, personality development, conflict and anxiety, defense and coping mechanisms.

SS 310 Contemporary Social Problems (3-0)3

This course deals with a series of contemporary social issues such as minority problems, violence, and population.

SS 315 Sociology of Deviance (3-0)3

Examination of the concept of deviance in sociology and its implications for the study of contemporary social behavior. The application of this concept to the study of mental health, alcoholism, drug addiction, and crime.

SS 320 Urban Sociology (3-0)3

Development of urban communities. Factors in city growth. Ecology of cities. Social organization of modern communities and metropolitan regions.

SS 322 Moral Problems in a Technological Age (3-0)3

The course will deal with contemporary social issues such as, war and peace, prejudice and race relations, inter-faith tensions, changing sexual patterns, and ecology.

SS 335 American Economic History (3-0)3

A study of the growth and development of the American economy from its European origins to the present.

SS 340 The United States: 1945 to the Present (3-0)3

An historical study of the United States since World War II.

SS 352 Contemporary Political Theory (3-0)3

An examination of contemporary political theory and its relation to current social problems.

SS 360 Government of China (3-0)3

An in-depth study of the politics of the Chinese People's Republic, including its history, ideology, internal politics, and foreign policy.

SS 362 Social Psychology (3-0)3

A seminar involving the problem of social order, the socialization process, social interaction, and the maintenance of social order.

SS 401 Afro-American History (3-0)3

An historical study of the patterns of racial relations and the participation of Afro-Americans in the social, economic, political, and cultural life of the United States. The topics covered include the origins and development of the slave system, the Civil War and Reconstruction, urbanization, the Civil Rights movement, and "Black Power."

SS 404 Technology and Social Change I (3-0)3

An examination of the impact of technology on contemporary man and society. Topics include the military-industrial complex, technological elites, and the role of the engineer.

SS 405 Technology and Social Change II (3-0)3

A continuation of SS 404. Topics include the impact of technology, politics, education, and the critics of technology.

SS 406 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles" — the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 407 The Technological Future: The Social and Political Aspects (3-0)3

A continuation of SS 406. Lectures, and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 410 History of Science and Technology (3-0)3

Science from the Middle Ages to the present. The scientific revolution of Copernicus, Galileo and Newton. Biology, evolution, relativity and 20th century science. Relationship of science to technology and both to society.

SS 412 Quantitative Methods in History and Political Science (3-0)3

The application of statistical methods and mathematical modeling to problems in history and political science. Students will be encouraged to undertake individual or group projects using the computer.

SS 451 History of France (3-0)3

The History of the development of ideas and institutions in modern France from the age of absolutism through the mid-twentieth century.

SS 452 Seminar in Recent American History (3-0)3

A study of selected problems in American History.

SS 453 Seminar in Modern European History (3-0)3

A study of selected problems in Modern European History.

SS 454 Seminar in Political Science (3-0)3

A study of selected problems in Political Science.

SS 455 Seminar in Psychology (3-0)3

A study of current trends in Psychology.

SS 456 Seminar in Sociology (3-0)3

A study of current trends in Sociology.

SS 460 Elements of Urban Affairs (3-0)3

Survey of the field of urban affairs including housing, intergovernmental relations, transportation, human resources, and the urban environment.

SS 461 Studies in Regional and Metropolitan Development (3-0)3

Examines interrelationships between economic, social land use and transportation planning at the regional and metropolitan levels.

SS 462 Urban Reform (3-0)3

An examination of the alternatives in urban reform. Topics to be covered include social welfare programs, urban renewal, and planned cities.

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles have been applied by the United States are examined through case studies.

SS 472 National Security Policy (3-0)3

A study of the relationships of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of natural security.

SS 474 Cultural Anthropology (3-0)3

A seminar analyzing various living societies and their cultures in terms of social adjustment to recurring needs.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U.S.S.R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviet state; the Stalinist period; and current domestic and foreign problems.

SS 482 American Urban History (3-0)3

The origin and development of the American city. The topics covered include police, poverty, city politics, and city planning.

SS 483 The Development of Western Civilization: To 1453 (3-0)3

The history of the development of ideas and institutions from democratic Athens to the renaissance.

SS 484 The Development of Western Civilization: Since 1453 (3-0)3

The development of ideas and institutions from the renaissance to the mid-twentieth century.

SS 485 Comparative World Governments (3-0)3

A study of comparative politics concentrating on Europe and the Third World. Emphasis will be given normally to England, France, the Federal Republic of Germany, the Soviet Union, China, and India. The analysis of these countries will include discussions of national character, history, the social and economic structure, and the political arrangements within each country.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 489 Political Parties in the United States (3-0)3

A study of voting behavior, policy making, and the historical development of American political parties.

SS 497 Tutorial in the Social Sciences (3-0)3

Individual directed study under the guidance of individual members of the department.

SS 528 Social Ecology (3-0)3

This course provides the student with an exposure to man's interrelationship with his total environment and its effects on social behavior.

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